UNITED STATES ENVIRONMENTAL PROTECTION AGEN
REGION VIII
999 18th STREET - SUITE 500
DENVER, COLORADO 80202-2466

AUG 23 1995

Ref: 8WM-C

David Holm, Director
Water Quality Control Division
WQCD-DO-B2
Colorado Department of Health
4300 Cherry Creek Drive South
Denver, Colorado 80222-1530

Re: Sunnyside Mine Lawsuit

Dear Mr. Holm:

Thank you for the opportunity to consult with you concerning this case. EPA is pleased that Colorado has chosen to use a watershed approach to address point source and non-point source pollution in the Animas basin. However, we are concerned that the proposed agreement will not conform with EPA's position on several key issues relating to hard rock mines and the Clean Water Act (CWA). In the following paragraphs, we explain EPA Region VIII's position relating to the issues at this site.

Ground Water Hydrologically Connected to Surface Water (including seeps)

It is EPA's position that seeps and other ground water discharges hydrologically connected to surface water from mines, either active or abandoned, are discharges from point sources and are subject to regulation through an NPDES permit. See Sierra Club v. Colorado Refining Company, 838 F. Supp. 1428 (D. Colo, 1993). Therefore, any seeps coming from identifiable sources of pollution (i.e., mine workings, land application sites, ponds, pits, etc.) would need to be regulated by discharge permits. The consent decree is not a substitute for the permit requirement.

As EPA stated at our last meeting, it is our position that the trading of point sources and non-point sources (the so called "bubble" approach) is acceptable only if the facility is subject to an NPDES permit. In the case of Sunnyside mine, we suggest that a TMDL approach be utilized to determine the appropriate permit limits. We do not agree that a permit is not required for the seepage, and we would consider the facility to be discharging without a permit when the seepage begins. Further, this application of the Clean Water Act is consistent with the approach followed at other sites in Colorado such as Eagle Mine, Conoco, Colorado Refining, and Climax Urad.

Appropriate Clean Up Goal

As stated above, we believe that a TMDL approach should be used to establish permit limitations that would be tied to an in-stream compliance point. We are concerned that the proposed agreement with Sunnyside Mine will make the downstream aquatic life goal unreachable. If Sunnyside is allowed to clean up only to the goal in the agreement (520 μg/l zinc), the seepage from the workings in the long-term could prevent compliance with the underlying zinc standard and the establishment of a fishery.

It is our understanding that a strong consensus has been reached among the Division, the Water Quality Control Commission, EPA, Sunnyside Gold, and the other stakeholders in the basin that water quality improvement sufficient to support some type of aquatic life use (e.g., brown trout) is an appropriate goal. Based on this understanding, we do not understand why the proposed agreement does not appear to support that long-term goal. While we recognize that there are questions regarding the appropriate numeric standard for zinc, and there are questions regarding the potential effectiveness of the various proposed clean-up projects, there is little question that further water quality improvement is necessary. We are hopeful that you and the Division will be able to explain how the proposed settlement agreement supports, or at least is compatible with, the long-term goal of improving water quality in the Animas River. The enclosed list of questions and comments is intended to provide further detail regarding this concern.

Ability of Projects to Meet Clean Up Goal

We are concerned that the combined results of the "A List" and "B List" of projects will fail to meet even the current goal of 520 μg/l zinc. Performance goals should be implemented for non-point source clean ups. There should be a provision in the agreement for review of the success of the non-point source clean-ups with the ability to require further and/or different measures if the measures implemented fail to adequately remove the projected zinc load. In addition, contingencies should be built into the agreement to require long-term active treatment if the A List and B List clean-ups do not remove enough zinc.

Maintaining Water Quality (Financial Guarantee)

It is of increasing importance to financially guarantee compliance with environmental requirements at all phases of the mining operation including post-closure. This has been mentioned by both Region VIII and EPA Headquarters' staff during discussions of environmental impact statements and NPDES permits for new mines. Clearly, the public's financial costs of Summitville also provide a strong argument for financial guarantees. Therefore, we do not feel comfortable allowing only Sunnyside to sign the agreement. The agreement should be signed by Sunnyside and Echo Bay (the parent corporation).

If you wish to request a conference call to further discuss these issues or if you have any other comments please contact me.

Sincerely,

Max H. Dodson
Director
Water Management Division

Enclosure

cc: Pat Nelson, CDPHE

1. **What are the Division's long-term goals for improving zinc concentrations in the Animas River basin?** We support the Water Quality Control Commission's goal of improving water quality in the basin. However, the proposed settlement seems to be directed toward simply maintaining existing zinc concentrations.

2. **Why is the existing 85th percentile zinc quality of 520 ug/l in segment 4a being used as a water quality goal, when support of the current designated use in this segment seems to require that a lower concentration be reached?** The Commission has adopted a chronic zinc numeric standard (effective in 1998) of 225 ug/l. That numeric standard is intended to prevent chronic toxicity to brown trout. The current designated use of segment 4a is Aquatic Life Cold 2, and the Commission has adopted a use of Aquatic Life Cold 1 that is scheduled to become effective in 1998. Why is 225 ug/l (or some other level deemed protective of aquatic life) not being used as the goal? Does the Division believe that 520 ug/l is protective of the desired aquatic life use?

3. **Why has the Division not prepared a basin-wide assessment of all zinc sources and allocated to Sunnyside a reasonable portion of the load reductions that will be necessary to protect the designated use in segment 4a?** Eventual support of aquatic life uses seems to require reductions in zinc loadings basinwide (particularly if brown trout is the goal). Clearly, the Sunnyside Mine cannot be held responsible for all of the required reductions. But why should they not be held responsible for a portion of the reductions that will be necessary? We believe that such an approach is reasonable given the mine's request for final closure and release from permit responsibilities.

4. **Once execution of the settlement agreement is completed, what further opportunities for reductions in zinc loadings will exist at that point?** One outcome of the settlement will be that many of the promising opportunities for reducing zinc loadings will be exhausted, leaving an uncertain path toward future improvements. Has the Division identified opportunities for reductions in zinc loadings which are not included in the list of mitigation projects, and will they reasonably provide an opportunity for improving zinc concentrations to levels that will protect the desired aquatic life use?

5. **What further responsibilities will Sunnyside Mine face if, following completion of the settlement agreement, monitoring data show that zinc loadings and ambient concentrations increase?** There seems to be substantial uncertainty regarding the potential effectiveness of the plug and the loading reductions possible from completion of the mitigation projects. What contingencies are included in the settlement agreement in the event that ambient zinc concentrations increase?

[59] From: MELANIE PALLMAN at R8WM1 7/10/95 7:56AM (1570 bytes: 21 ln)
To: VERN BERRY, ROBERT BURM, KAREN HAMILTON, ORVILLE KIEHN, PEGGY LIVINGSTON at R8RC, DAVE MOON, PAUL OSBORNE, MIKE REED, PAUL ROGERS at R8HWM1, CAROL RUSSELL, ELYANA SUTIN at R8RC, ROBERT WALLINE, BILL WUERTHELE, BRUCE ZANDER
Subject: Briefing for Max
------------------------------ Message Contents ------------------------------

I have scheduled a briefing for Max regarding our recommendation for Sunnyside mine on Thursday July 13th 9:30 a.m. - 10:30 a.m. in the Conference Center. I am trying to set up a meeting with Dave Holm (which we may need to schedule while Max is out since he will be out for two weeks - if Max supports our recommendation, then I think we should meet with Holm).

I will be typing up the notes from our last meeting and our recommendation as a handout at the briefing. We also discussed a handout on the projects in the area that are funded under 319 (which I asked Carol Russell if she could do). Finally, a handout on the history of the site would also be helpful - I will work on this, but I will probably need Rob's help since I think he has the most history there. Carol - could you also draw your swell map again?

Carol and Rob - is this going to be a problem?

I will try to distribute handouts in advance, but no promises. Hope to see you there.

From: ORVILLE KIEHN 7/10/95 9:10AM
To: MELANIE PALLMAN
Subject: Re: Briefing for Max
------------------------------ Message Contents ------------------------------

Sorry, again I'm on the run, this time to Spokane, WN through July 13th, back on the 14th.

Earlier I sat in on the first Dave Holm briefing for Sunnyside Mine re:concerns that the State of Colorado had over the proposed company plan. Plugging and backing up the mine pool to probable pre-mining water table level(s) and the need for technical geology and hydrogeology understandings were discussed by our hydrologists at that time. The need for a fail-safe backup water treatment understanding in writing and financial assurance should the mining company plan fail were also discussed.

Rob has excellent background and technical expertise and would call on me to assist where appropriate.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION VIII
999 18th STREET - SUITE 500
DENVER, COLORADO 80202-2466

Ref: 8WM-C

Enforcement Sensitive

MEMORANDUM

TO: Vern Berry, 8WM-C
Bob Burm, 8WM-C
Karen Hamilton, 8WM-WQ
Karen Kellen, 8RC
Orville Kiehn, 8WM
Peggy Livingston, 8RC
David Moon, 8WM-WQ
Paul Osborne, 8WM-DW
Mike Reed, 8WM-C
Paul Rogers, 8HW-SR
Carol Russell, 8WM-WQ
Elyana Sutin, 8RC
Rob Walline, 8WM
Bill Wuerthele, 8WM-WQ
Bruce Zander, 8WM-WQ

FROM: Melanie Pallman, 8WM-C

SUBJECT: Sunnyside Mine Meeting

DATE: June 16, 1995

Thank you for you interest in the Sunnyside Mine closure lawsuit. Please review the attached materials and be prepared to raise issues and concerns at our meeting scheduled for **Wednesday,** JUNE **~~May~~ 28th from 1:00 - 3:00 in the Conference Center.** As a reminder, the purpose of the meeting is to try to reach a consensus on EPA's position concerning the proposed consent decree. The attached documents should be considered FOIA exempt (deliberative process) and should not be released.

SUNNYSIDE GOLD CORPORATION
AN ECHO BAY COMPANY
P.O. Box 177 • Silverton, CO 81433
Phone (303) 387-5533 • Telecopy (303) 387-5310

CONFIDENTIAL
FOR SETTLEMENT PURPOSES ONLY

April 4, 1995

J. David Holm, Director
Water Quality Control Division
Colorado Department of Public Health and Environment
4300 Cherry Creek Drive South
Denver, CO 80222

Dear Dave:

Thank you for the opportunity to meet with you to discuss Sunnyside Gold Corporation's proposal. This voluntary mitigation and closure plan addresses the requirements of both the Water Quality Control Division (WQCD) and Sunnyside Gold Corporation (SGC) and it should allow the parties to reach an acceptable settlement of the outstanding issues. We contemplate that a Consent Decree incorporating this proposal will be negotiated by the parties and counsel within sixty days and then entered by the District Court.

OPTIMISTIC

Need to incorporate public comm

History and Background

SGC acquired the assets of the historic Sunnyside Mine in 1985, reconditioned the mine and mill, and produced gold from 1985 to 1991. SGC's mining and milling facilities were closed in August of 1991 due to lack of ore reserves and depressed global metal markets. Prior to the decision to implement final closure, SGC developed a strategy to work on reclaiming areas that were deemed unnecessary for any potential future production. A small group of the local workforce has been kept busy as a result of this program and then transferred on to final closure activities.

During the summer of 1991, SGC began looking at what would be required for final closure and release from permits from both the WQCD and the Division of Minerals and Geology, Mined Land Reclamation (MLR). The MLR permit stated that upon final closure of the mine, concrete bulkheads were to be placed in the tunnels to prevent water from exiting the mine via the American Tunnel and Terry Tunnel.

Hydro-Search of Reno, Nevada was contracted to do a study called Preliminary Characterization of the Hydrology and Water Chemistry of the Sunnyside Mine and Vicinity. The report was completed in February of 1992 and indicated that it would be possible to return the hydrologic flow to an approximation of premining conditions. SGC also contacted Dr. John Abel Jr., Mining Engineer, for evaluation to see if deep seated bulkheads were practicable at Sunnyside. A letter report from Dr. Abel helped to reinforce the Hydro-Search work and encourage SGC to pursue the option of placing hydraulic seals in the Sunnyside Mine.

SGC announced at a joint meeting between the staff people of WQCD and MLR in June 1992, the intention to bulkhead the mine in order to fulfill the terms of its permits and obtain permit release.

Through 1992, SGC, Hydro-Search and Dr. John Abel Jr. gathered additional information necessary to evaluate the hydraulic and hydrochemical aspects of the proposed bulkheads as well as develop detailed engineering plans for the project. This work was completed early in 1993 and a technical revision of SGC's reclamation permit was submitted to the MLRD with a copy sent to the WQCD.

A joint meeting was held to discuss and address technical and regulatory concerns with the project in April of 1993. The technical concerns of MLR were addressed by early fall, however the WQCD still had regulatory concerns. A decision was made to move forward with Mined Land Reclamation Board (MLRB) approval with stipulations that SGC have WQCD approval prior to valve closure. The technical revision was approved by MLRB in November 1993. No such approval

After MLRB approval, SGC and WQCD tried to resolve differences on the requirements necessary for the hydraulic seal project to move forward. A major issue was whether or not SGC is responsible for seeps and springs that may be reestablished following mine closure.

SGC believes that final reclamation of the mine should include plugging of the American Tunnel and ultimate termination of the discharge at the portal. This would conclude SGC's obligation to have a point source discharge permit. The reestablishment of approximate historic pre-mining hydrologic conditions underground will ultimately lead to reemergence of natural springs and seeps as water no longer moves through the geologic structures to exit the mine tunnel. Such seeps and springs, in SGC's view, would not be subject to permit requirements as point sources. The WQCD has taken a contrary view.

In May of 1994 SGC filed a declaratory judgment suit in district court to resolve this issue. Since filing, both SGC and WQCD have been trying to reach a settlement which would allow SGC to move forward.

The purpose of this proposal is to be the basis of a Consent Decree settlement of the lawsuit and the permit and regulatory issues. If the actions contemplated by the settlement do not achieve the conditions for permit release contemplated by this proposal, then the parties would be free to pursue the legal positions they have taken or to otherwise seek to resolve the matter.

SGC and WQCD have worked towards reaching a framework of voluntary offsite cleanup efforts in order to satisfy each other's requirements. WQCD's major goal is to allow SGC a method of release from permits without degrading the water quality in the Upper Animas Basin. SGC's major goal is to expedite the closure and reclamation at Sunnyside including final release from all CDPS/NPDES permit (including stormwater requirements). This proposal is made to reach a voluntary agreement that would allow each party to realize its objectives without taking the litigation to a decision. The actual settlement document will make clear that neither party is conceding its legal position on the unresolved regulatory issues.

Voluntary Plan Summary not really

American Tunnel/Terry Tunnel

During 1995 SGC will close the valves at the Terry Tunnel plug and at the property line in the American Tunnel. Once closed, the mine pool will start to build and will be monitored for pool height. The pool will be considered at equilibrium when the rate of rise of the mine pool has leveled off. Equilibrium will be defined by mutual agreement between SGC and DMG. Once the pool is at equilibrium, SGC envisions the placement of additional hydraulic seals downstream of the property line seal to eliminate the American Tunnel portal discharge and to allow final reclamation of the surface facilities as currently permitted. [redacted]hould maintenance of the portion of the American Tunnel downstream of the property line seal be undertaken by other parties, then SGC will be released from any continued permit obligation. Downstream hydraulic seals or other hydrological controls will be implemented as necessary to maintain ambient quality, as defined, below Silverton or satisfy MLR permit requirements. need defined

Attorney Client Work Product

Mitigation Projects

SGC is submitting [redacted] the WQCD and SGC achieve their goals in the Upper Animas Basin. SGC is willing to complete as many as necessary for achievement of our mutual goals. [redacted] For mitigation sites, a monitoring schedule is outlined under monitoring requirements.

what is meant by this?

Cement Creek

The WQCD has expressed concern about potential near-term adverse impacts on the Animas River from plugging and cessation of treatment at the American Tunnel. SGC's consultants have not projected such impacts. In order for SGC to allay those concerns and close the valves at the Terry Tunnel and at the property line in the American Tunnel, 8000 feet from the portal, SGC will take steps to create a water quality "cushion" within the Upper Animas system for potential additional loading without change in Ambient Quality below Silverton. To create this cushion, SGC would divert flow from the main stem of Cement Creek, including north fork of Cement Creek, to the current water treatment system for treatment. Upon valve closure at the Terry Tunnel and at the property line in the American Tunnel, SGC will adjust the treatment facilities as necessary to accommodate the remaining flow from the lower American Tunnel and the diverted flow from Cement Creek. This diversion would be regulated in amount from total flow in low flow months up to the equivalent flow, if necessary, lost to the treatment system by sealing during high flow. This diversion will be monitored and controlled to manage impacts at the reference point in the Animas River below Silverton. Once other mitigation steps take effect, the amount of diversion will be decreased and stopped when, in SGC's opinion, they are no longer necessary. The water treatment facility will remain in operational condition until permit release. Upon permit release, the facility will be dismantled and the treatment ponds and surface disturbances reclaimed.

Is the present system capable of treating

CDPHE needs role here

Conditions of Permit Release

When the conditions described below have been accomplished, SGC will be released from its CDPS/NPDES permits including [redacted] is anticipated this will be at the same approximate time that the MLR permit is finally released. No future point source permits will be required by WQCD for seeps or springs which may emerge or increase after tunnel plugging.

needs to be more laid out.

reclamation related

Attorney Client Work Product

J. David Holm, Director
April 4, 1995
Page 5

Definition of Ambient

The ambient quality reference point will be located below the Town of Silverton after the confluence of Cement Creek, Mineral Creek and the Animas at the beginning of Segment 4a as defined by the WQCC. Samples collected to date have been taken at a sample point named [redacted] SGC would continue sampling there.

The ambient quality of Segment 4a listed in the stream classifications and water quality standards for dissolved zinc is 520 micrograms per liter. By definition, the ambient value is simply the value of the sample at the calculated 85th percentile position of available information arranged in descending order. Fifteen percent of the samples are expected to exceed the ambient quality. The sample collection for this site started in January 1989 and continues today. The ambient standard, however, uses all information gathered during the years 1989 through 1993.

SGC has reviewed the sample results for dissolved zinc and takes issue with the conclusions derived from the small number of samples collected during low flow winter months. Metals loading varies seasonally, with highest concentrations found in the low-flow winter months. Plotting of the data shows that all exceedences of ambient standards occur in the low flow months between November and April and that consistent data collection for low flow months has not been done at the frequency of other months. [redacted] A more accurate value would be approximately 550 micrograms per liter Zn.

SGC proposes that the lower defined ambient quality for dissolved zinc (520 micrograms per liter) can be used as a reference point if all data collected and used in modelling are weighted to sample timing as has been done for the establishment of ambient quality.

Need explana

Both SGC and WQCD agree that dissolved zinc is the primary metal for which success or failure of sealing the mine is to be evaluated. Zinc is chosen because of its mobility (ie conservative nature) within the Upper Animas River system. When zinc is removed from the system, other metals will likely also be removed.

How defined

Voluntary Mitigation Projects

SGC is listing nine mitigation projects which will offset potential loading increases resulting from waters returning to their natural flow paths around the Sunnyside Mine. The projects are

Attorney Client Work Product

Where is list?

listed as "A" list or primary (those projects on which work will commence after the hydraulic seal valves are closed) and "B" list or secondary (those projects which may need to be completed in order for the dissolved zinc quality at Segment 4a to remain at ambient conditions). The secondary list will be worked on after the primary list has been completed and the quality at the reference point can be monitored to see the effects of the completed work on reducing the dissolved zinc loading from the Upper Animas Basin. Completion of all projects on the secondary list may not be necessary if enough room is created in the Animas to maintain ambient quality and allow for final closure of Sunnyside facilities including permit release.

It is not the intention of SGC to overstudy these projects but to evaluate, engineer and complete work in a safe, proper and expedient manner. All work on mitigation sites will be BMP with the focus on reducing the dissolved zinc loading at the reference [redacted]. SGC would perform the work in a workmanlike manner and would submit documentation of projects to demonstrate implementation of best management practices ("BMP"). SGC, WQCD and MLR need to conceptually agree that these projects would reduce metals loadings in the Upper Animas as well as reclaim abandoned mine/mill sites.

SGC is listing the conceptual projects for concurrence by the WQCD and MLRD as to the viability of the project as well as an understanding of the BMP technique envisioned to be used at each site. After field inspection of the projects some modification of the work may be necessary depending on conditions occurring at each site.

Mitigation on sites not owned or controlled by SGC will require permission of property owners to enter their property to evaluate and do mitigation work. Should permission not be granted, other projects may need to be substituted on the list. Should SGC identify more beneficial projects, they will replace other projects on the "B" or secondary project list with concurrence from both WQCD and MLR.

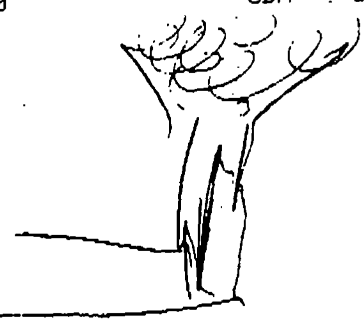
Prior to commencing work, SGC will supply engineering data to both WQCD and MLR on voluntary mitigation projects.

"A" List - Primary Voluntary Projects

- Sunnyside Mine Pool

  Part of filling of the mine pool would be to introduce high pH water into the pool during filling. The projected target pH of mine water would be 8.0 to 9.0 versus current 6.5 at the American Tunnel. This would allow for the pool to reach equilibrium from a basic pH as oxygen is depleted rather than from an acid pH.

Impact to ... time. Will the pH deteriorate? How long will it be subject to ...



Will this have an impact at low flows.

- Mine Waste Dump - South Fork of Cement Creek

  The remainder of the mine waste dump would be removed and consolidated with addition of high pH material for stability. The area underlying the waste dump will be revegetated in accordance with SGC's MLR permit. The consolidated material will be capped and revegetated.

- Surface Mill Tailings at Eureka - Eureka Townsite

  The surface tailings at Eureka will be removed and consolidated with addition of high pH material for stability. Due to this area existing in an alluvial fan which consists primarily of gravel, no revegetation would be done. The consolidated material will be capped and revegetated.

- Gold Prince Mill Tailings and Closure Bulkhead - Head of Placer Gulch

  The closure bulkhead which prevents entry would be reinforced and portal reshut to create a water retaining bulkhead. The surface mill tailings will be removed and consolidated with high pH material. Disturbances would be revegetated. The consolidated material will be capped and revegetated.

- Koehler Longfellow Portal and Mine Waste Dump - Headwaters of Mineral Creek

  A bulkhead would be installed in the adit to return the hydrologic regime to approximate premining conditions. The mine waste dumps would be removed from the creek bottoms and consolidated with high pH material for stability. Areas that do not occur within talus slopes will be revegetated. The consolidated material will be capped and revegetated.

"B" List - Secondary Voluntary Projects

- Boulder Creek Mill Tailings - Upstream of confluence of Boulder Creek and Animas River

  The tailings will be removed and consolidated with high pH material for stability. The disturbed areas will be revegetated. The consolidated material will be capped and revegetated.

- Pride of the West Mill Tailings - Howardsville

J. David Holm, Director
April 4, 1995
Page 8

The historic tailings would be removed on the west side of the property away from streams. The material removed would be consolidated and the disturbed areas revegetated.

- Columbus Mine Portal - Animas Forks

  A bulkhead will be installed in two adits to prevent direct mine discharge in order to return the hydrologic regime to near premining conditions.

- London Portal - Headwaters of Animas River

  A bulkhead will be installed in the adit to prevent direct mine discharge in order to return the hydrologic regime to near premining conditions.

Schedule

The voluntary mitigation projects will start shortly after valve closure and diversion of Cement Creek. Construction is confined to summer and fall months due to the heavy winter snowfalls that occur in the Upper Animas Basin.

The "A" list of primary projects will be completed within the first two field seasons. Monitoring at the reference point for removal of metals loading begins concurrently. Upon completion of the "A" list of voluntary projects, SGC will then start on the "B" list or secondary list of voluntary projects. If the projects are successful in removing dissolved zinc loading from the Upper Animas River all voluntary projects required to maintain ambient quality will be completed in 3 to 4 years.

Permitting

Three permitting issues will need to be resolved as part of a final settlement:

<u>General Permit</u>. The parties will negotiate a water quality permit which will be in the nature of a general permit to cover all of the mitigation projects contemplated by the agreement. The general permit will be based on best management practices for the mitigation projects. It will provide liability protection, to the maximum extent allowed [redacted]he general permit will expire when the mitigation projects have

been completed, and there will be no continuing obligation of SGC to maintain water quality permits or treatment at those sites[redacted]

CDPS/NPDES Permit Amendments. SGC does not contemplate that any additional treatment will be necessary at the Terry Tunnel. SGC will continue to operate the American Tunnel water treatment facilities until they are no longer necessary to maintain the dissolved zinc criterion at the reference point in the Animas River below Silverton. Diversion of Cement Creek waters, which are different in character from mine water, may bring new background toxic conditions into the American Tunnel water treatment system. Since the fourth quarter of 1993, SGC has passed all chronic Whole Effluent Toxicity (WET) tests at the Instream Waste Concentration (IWC) ratio, which demonstrates that the treated mine water discharge has not been toxic. [redacted] standards, there will be an improvement in the Animas Basin, as well as an acceptable compliance point for enforcement.

At the conclusion of the requirements of the Consent Decree, the existing CDPS/NPDES permits would be released. [redacted]

Other Permits. If other environmental permits are required for the mitigation projects, such as Section 404 permits or "reclamation only" MLR permits, WQCD will cooperate with SGC in obtaining such permits from the appropriate agencies so that the projects can go forward in a timely fashion. If necessary permits are ultimately denied by the responsible agency, that portion of the mitigation projects will be deleted from the requirements of the Consent Decree.

Monitoring Requirements

As long as the Consent Decree is in effect, SGC will monitor the following sites according to the schedule below.

need defined → need

SGC Permitted Area

- American Tunnel Inflow - Sampled monthly for dissolved and total metals until no flow exists or permits are released. → with runoff this may change. Do we have data on how quickly it changes

- Cement Creek Inflow - Sampled monthly for dissolved and total metals while Cement Creek is diverted. is there a relationship

- American Tunnel Effluent - Sampled weekly for total metals and monthly for dissolved. Below the ~~confluence~~ of the American Tunnel effluent and Cement Creek will be sampled monthly for total and dissolved metals until Cement Creek diversion and treatment of American Tunnel waters cease. → depend on changes in Cement Creek

- Terry Tunnel Inflow - If flow exists, inflow will be sampled, when accessible, for dissolved and total metals until ~~no flow~~ exists or permits are released. → If flows exist we may need

- Terry Tunnel Effluent - If treatment is required due to flow ~~from~~ portal, effluent will be sampled, when accessible, weekly for total metals and monthly for dissolved until no flow exists.

- Sampling of other areas per SGC's MLR permit will continue until SGC is released from its obligations by MLRD. Sampling of other areas per SGC's CDPS/NPDES permits will continue until SGC is released from those permit obligations.

Mitigation Sites

SGC will monitor mitigation project sites for dissolved base metals starting in 1995. Sampling will stop two years after each project is completed. If appropriate, SGC will collect a sample above, below, and at the mitigation site. Four sample periods will be done yearly with one at high flow, when the site is accessible, and one at low flow, late fall.

Reference Point

- Reference point will be sampled for dissolved metals at a weighted frequency comparable to that existing for the time period of 1989 through 1993. This sampling will continue until SGC is released from CDPS/NPDES permit requirements.

RRL ? Loadings (a, 4a - any adverse impact from another site others work. Hopefully [illegible] Mitigate

J. David Holm, Director
April 4, 1995
Page 11

Potential Adverse Effects by Others

Should new adverse effects on the Upper Animas Basin occur through man-made or natural causes, SGC will monitor these causes so that a mathematical adjustment can be made to the Calculation Methodology for Ambient Quality in the Animas River below Silverton.

Calculation Methodology

SGC will be released from its permits when information exists to calculate that the ambient dissolved zinc criterion at the reference point will not be exceeded if treatment of Cement Creek is stopped. The timing of this calculation is addressed below.

The calculation will require information on quantity of flow and concentration of dissolved zinc in the water at both the reference point and at all streams of water treated at the American Tunnel. On a monthly basis the following calculations would be made to determine a calculated quality at the reference point. The calculated quality could then be compared to the established ambient quality.

1) Reference point quantity x reference point quality = reference point loading

2) Cement Creek inflow quantity x Cement Creek inflow quality = Cement Creek loading

3) American Tunnel inflow quantity x American Tunnel inflow quality = American Tunnel loading

4) Treatment discharge quantity x treatment discharge quality = treatment discharge loading

5) Adverse impact quantity x adverse impact quality = adverse impact loading (activities of others)

6) Reference point loading + Cement Creek loading + American Tunnel loading - treatment discharge loading - adverse impact loading = calculated loading.

7) Calculated loading ÷ reference point quantity = calculated quality.

[illegible] credit for loading from [illegible]

This calculation will be carried out based on monthly sampling to determine how the Upper Animas Basin is reacting to voluntary mitigation. Based on this calculation SGC will be released from its permits when water treatment is stopped, without long-term monitoring.

Timing needs to be addressed to ensure stability

Attorney Client Work Product

Att Client

Reference Point

The reference point will be at the WQCD's sample point A-72 below Silverton near an established USGS gauge and below the confluence of Cement and Mineral Creeks with the Animas River. The point will be sampled as described above and [redacted] ents).

Estimated Timing

Based on historical information, Hydro-Search expects the final mine pool elevation to be at equilibrium at approximately 11,500 feet above mean sea level. Their volume calculation gives total cumulative gallons at equilibrium of approximately 195 million gallons. Hydro-Search's two methods of estimating the schedule of natural mine flooding predict that the water level will substantially reach equilibrium (86% of equilibrium) in one to ten years.

SGC can pump an additional 200+ gallons per minute into the mine pool during summer months, thus shortening the total fill time by 12% of total gallons for each year that water is pumped into the mine. If SGC pumps additional water into the mine, total fill time would be reduced by about 12% per year of pumping, and fill time may be reduced to between one year and four years.

Once equilibrium of the mine pool is established, the terms of SGC's MLR permit allow for 2 years of monitoring prior to considering the project successful. The 2 years is to allow for evaluation of short circuits of waters that might emanate from the Sunnyside workings and to evaluate the property line plug. After the deep seated bulkhead is determined successful, SGC would grout the pipes in the deep seated bulkhead at the American Tunnel and then start plugging of the lower American Tunnel waters.

WQCD has expressed a concern that enough time be allowed for the pool to reach equilibrium both in quantity and chemically. SGC proposes that a minimum time for permit release be 5 years after valve closure at the property line plug in the American Tunnel.

Not a ~~tab~~ more! Can't put time on it

The voluntary mitigation projects will start as soon as practicable after valve closure. The "A" list or primary projects will be complete within 18 months. Mitigation of the "B" list of projects would start after monitoring results from the reference point allow for evaluation of the specific number of projects necessary. All work would be completed by the end of the fourth field season.

Attached please find a flow diagram which shows the steps SGC is voluntarily taking in order to move toward final permit release.

To allow SGC to move this process forward to 1995 construction, prompt negotiation of the final agreement will be needed. If the WQCD agrees in principle with this proposal, we request that the WQCD confirm that agreement by a letter which would establish a non-binding agreement in principle.

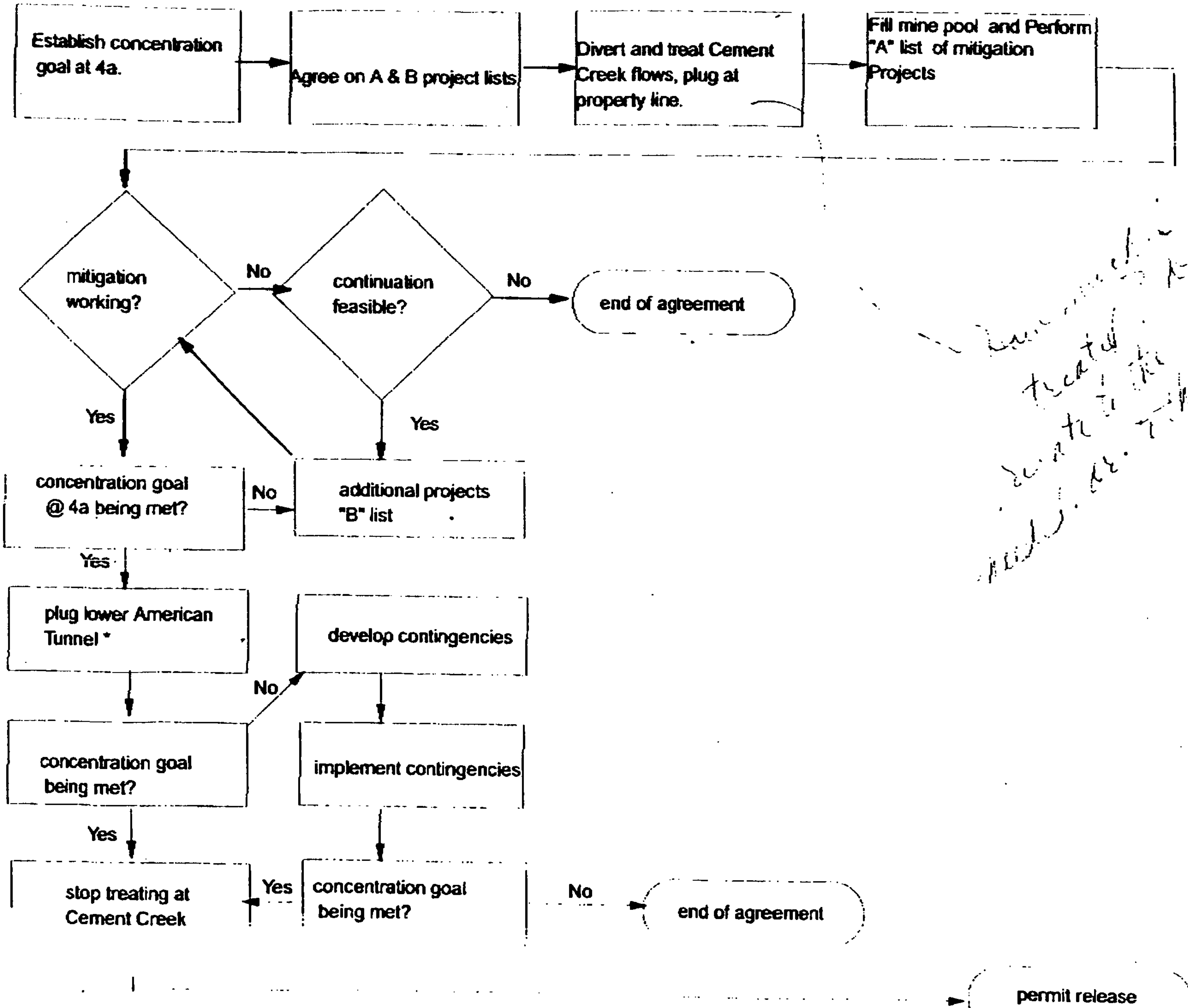
Sincerely,

William B. Goodhard wck

William B. Goodhard
Resident Manager

cc: Amelia Whiting, Esq. (w/enclosures)
Allen Sorensen (w/enclosures)

Settlement Flow Chart
Sunnyside Gold Corporation



* plugging of lower American Tunnel may

STATE OF COLORADO

Roy Romer, Governor
Patti Shwayder, Acting Executive Director
Dedicated to protecting and improving the health and environment of the people of Colorado

4300 Cherry Creek Dr. S.
Denver, Colorado 80222-1530
Phone (303) 692-2000

Laboratory Building
4210 E. 11th Avenue
Denver, Colorado 80220-3716
(303) 691-4700

Colorado Department of Public Health and Environment

May 12, 1995

Mr. William B. Goodhard
Resident Manager
Sunnyside Gold Corporation
P.O. Box 177
Silverton, CO 81433

RE: Discussion Items for May 17, 1995 Meeting

Dear Mr. Goodhard:

In order to facilitate our discussion on May 17, we felt that it would be advantageous to provide a listing of those areas which still need discussion or those technical items where the Division has questions and seeks clarification. The purpose of this letter is to provide you with this information. The following is a list of items which need discussion:

<u>Treatment of Cement Creek</u>

It is the Division understanding that Sunnyside Gold Corporation and Echo Bay Mines ("SGC") have committed to treatment of Cement Creek in an effort to provide a loading deficit in the stream to absorb the anticipated increased loading from the plugging of the American Tunnel. This concept is acceptable to the Division. We do, however, need to better understand how the system you proposed will work. Could you please provide us with an explanation of how this will physically be accomplished. In particular, how will the decision be made on the total quantity of flow to be diverted. What is the anticipated loading removal that SGC is expecting by the diversion and treatment of Cement Creek? We assume that the zinc loading to be removed from Cement Creek will be equal to the anticipated loading from the plugging. (See January 13, 1995 letter to Mr. William Goodhard from the Division for possible loading scenarios.) Has SGC evaluated whether there is sufficient loading in Cement Creek at the point of the American Tunnel to balance the anticipated loading? Our quick calculations would indicate that it may be difficult to meet the most optimistic scenario under some low flow conditions. What is the expected quality of the discharge from the combined system? Will the treatment system be capable of handling the flow both hydraulically and chemically?

The process used to decide when to cease treatment of Cement Creek needs to be further developed. Such a decision should include some level of input from both the Division and Division of Minerals and Geology.

Definition of Ambient

The Division has evaluated your comments concerning the definition of ambient and we have thought about how to impose the 520 ug/l in an efficient manner. The determination as to whether the water quality goal at A-72 is met should be based on using all of the paired streamflow and zinc concentrations data. At issue here is the need to determine the criteria to be used to evaluate whether the zinc concentration has increased, decreased, or not changed at A-72. The Division has established the 85th percentile zinc concentration standard, based on a simple rank ordering of the data for stations A-72 and RPS-82, as 520 mg/l. The following is a concept on which we would like your thoughts.

The existing concentration of zinc is a function of stream flow at A-72. The relationship between stream flow an the concentration of dissolved zinc shows that 520 ug/l zinc concentration, on average, corresponds to a discharge of 44 cfs which approximates the annual low flow. The attached graph illustrates the variability in the zinc concentration, especially at the low flow end of the curve. The flow-concentration "model", rather than a single number, allows use of the entire data set to evaluate change/no change in zinc concentration at A-72. For example, reduced zinc concentration would result in most or all of the data points falling below the existing line. Concentrations at a given flow above the line would indicate a lowering of water quality. This "model" assumes that the percent change in zinc concentration owing to BMP's and mine closure is uniform throughout the flow range of interest. The loading analysis done by the Non-Point Source Program for four synoptic events indicates that the load percentage from the various watersheds is based on a relationship between stream flow and concentration.

It was proposed by SGC that weighing samples to the low flow period on the theory that past sampling was biased toward high flows. The flow-concentration model makes use of what ever data is obtained. If unusually high flow or low flow conditions are encountered during the evaluation period, the flow-concentration model should be neutral. Moreover, the streamflow at which 85th percentile zinc concentration is expected to occur should not change, therefore, the traditional approach to setting an ambient standard can still be used. We can discuss this further at our meeting.

Voluntary Mitigation Projects

The list of mitigation projects is good. We would like to have additional information on the expected loadings to be removed by the projects. The Division needs to have a better understanding of the information that will be gathered prior to any remediation efforts. The Division will want to ensure that there are adequate reviews of the plans and there is a reasonable amount of information which supports the activities at the sites and that the likelihood for success is high. Specifically, detailed information as to where and to what extent the Koehler/Longfellow, Gold Prince, Eureka and South Fork of Cement Creek dumps and mill tailings will be removed. Both the Water Quality Control Division and the Division of Minerals and Geology must be involved in the process of design and in the implementation and final inspection of the A and B projects.

Additional information is needed on the proposal to fill the mine with alkaline water. While it would seem to be appropriate to accelerate the filling of the mine in order to determine what the impacts are in a shorter time frame, our concern is about over long term water quality impacts. Will the water eventually return to acidic conditions thus creating a water quality impact in the future? Will there be pockets of water in the mine which are not filled by the alkaline water? Has this been done anywhere else with success? The Division needs more information on this process. We would appreciate information on exactly how it will be done and what measures will be taken to ensure that the water is distributed through out the workings. How will SGC determine if it is working and the estimated time for the water quality to reach equilibrium?

Permitting

General Permit. The Division is willing to draft a permit for the work on all mitigation sites. We have several permits in a draft stage which would provide the coverage and flexibility you desire. It would require that there be no degradation in the water quality from your activities other than transient impacts associated with construction. However, we do not feel that we could finalize and issue such a permit in the time period you requested. We estimate 60+ days to get the permit to a stage where it can be public noticed. We would be willing to cover some of the activities, such as some tailings removal, under stormwater general permits. This would provide SGC with the coverage under a permit in less than 30 days and, therefore, allow some remediation to commence. We could also be working on finalizing a permit which deals with the other sites in question.

CDPS/NPDES Permit. The current permits for the American Tunnel, Terry Tunnel and Mayflower mill are expired and have been extended. It would be the Division's intent to maintain these permits until it is agreed that the permits no longer are needed. We do feel that they do need to be renewed so that they accurately reflect the current situation and standards. At this time we anticipate that the requirements to meet BAT will be the appropriate limitations, however we must evaluate the discharge and ensure that any permit limitations are in compliance with federal and state law and regulations. Has SGC evaluated what the quality of the discharge from the combined Cement Creek/American Tunnel discharge needs to be to meet the expected loading necessary to have no impact from the tunnel plugging? Concerning the inclusion of WET requirements, the Division feels that for the Terry Tunnel and the Mayflower Mill any discharges need to be in compliance with the WET requirements. Once the American Tunnel treatment system begins to treat Cement Creek, then the Division would agree that WET testing is not appropriate of the combined discharge.

The stormwater requirements state that a permit is necessary until bond release and/or stormwater no longer comes into contact with mining waste. This permit will be needed until the site meets the regulatory requirements for permit termination.

Monitoring Requirements

The Division needs more information relative to the monitoring plan. This is an important part of the agreement. It is important that the elements of the plan be outlined in detail to ensure that there will not be confusion in the future as to what is required. It is very important that both the Division and SGC have good data on which to base decisions. It is suggested that the monitoring plan required by DMG be combined with that proposed to meet our concerns. This would provide everyone with a good understanding of the area's water quality, avoid duplication of work and allow SGC to provide the same information to both agencies. The monitoring information required by DMG is also important to us. We have assumed that our monitoring program requirements would be in conjunction with DMG's requirements. Therefore we would expect that the data from the plans would be sent to both agencies and that the monitoring plan would be in place until both agencies agreed to any changes. The Agreement will need to specify the sampling and analysis techniques which will be used. Specific comments on your proposal are:

SGC Permitted Areas: It is not clear if the monitoring listed is in addition to CDPS permit requirements or are the permit requirements that SGC wishes to have included in the permit. There is not a list of what metals are meant by "dissolved and total metals". The specific parameters need to be listed in the final agreement. We would appreciate some clarification on the parameters which SGC was planning to include. There is concern that the quality of Cement Creek may change quickly especially during different portions of the year such as during spring runoff. Monthly monitoring may not be adequate to note changes in quality. Additional information is needed on how the diversion of Cement Creek will function before we can come to agreement on the proposed monitoring program.

Mitigation Sites: The time frame for monitoring at the mitigation sites should be based on the type of mitigation to be expected. The monitoring program proposed for these sites may be adequate for some however, others may need additional monitoring sites, additional parameters or need to be monitored for a longer period of time. It is suggested that the monitoring program be part of the submittal for each mitigation site.

Reference Point: The discussion on the reference point includes a discussion on the calculation of the reference point level and the necessary monitoring. It is proposed that SGC use only A-72 as a reference point. The WQCC adopted ambient standards for the Animas River between Maggie Gulch and Cement Creek. Mine closure may affect the zinc concentration in this segment, therefore a monitoring point should be established for this segment. A-68 would be a good location.

Besides points at A-72 and A-68, it is recommended that a monitoring point on Cement Creek, preferable at C-48 be established. Cement Creek has a similar flow/zinc concentration relationship as A-72. This point could be used to establish the amount of zinc level reductions required from the Cement Creek treatment plan. Monitoring at C-48 benefits SGC in that the need for additional mitigation projects could be more reliably determined than by depending on A-72 alone, and the Division would know the effectiveness of the plug. Cement Creek should not become a reference point because the possibility of the zinc concentration increasing in Cement Creek, however we do need to know what is happening in this segment.

It is not clear how SGC will determine if there are adverse impacts on the Animas from other parties. This is very important to SGC so that it is not held responsible for the exceedances of the 520 ug/l which are not the result of its activities. The Division feels that the burden must be on SGC for providing an affirmative defense on any exceedances. The Division would like to see the procedures that will be used to determine if there are adverse impacts.

The Division does not understand the calculation methodology outlined in your proposal. We would appreciate your clarification on this at the May 17 meeting. It seems that the reference point loading should be equal to the calculated loading at the reference point minus the loading of any adverse impacts. (It is suggested that the term "adverse impact" be defined in the agreement.)

The Division does not see the reference point as a goal or an indicator. This value is a baseline which will trigger required actions if exceeded.

Estimated Timing

The Division is not comfortable with committing to a five year time period from when the plug is placed at the property line to permit release. The Division will want to see the mine pool stabilized prior to permit release and have a good baseline of information which shows that the 520 ug/l is met and will continue to be met prior to allowing the permit to terminate. The inclusion of the alkaline waters may push the decision point somewhat further into the future. It is our understanding the DMG permit requires monitoring after equilbruim and is not tied to the date that the plug is closed at the property line.

Conditions for Final Permit Release

Items 1 and 7 do not necessarily agree. Item one says that the mine pool has reached equilibrium plus 2 years while item seven states that five years has elapsed since the valve was closed at the property line. While it is possible that these two could agree, it is also possible that equilibrium may not be reached in three years. If the mine takes 10 years to reach equilibrium, the time period for release could be 12 years after closing the plug at the property line.

The conditions outlined for permit release do not state that the quality of the Animas is acceptable. It is very important to the Division that any release from any additional requirements be contingent on the quality of the Animas.

Other Items.

There was an item which we discussed previously but on which your proposal was silent on, this is the need for public involvement. It is very important that the public which will be affected by the activities of SGC have the opportunity to review and comment on this agreement. The Division will not enter into an agreement which is opposed by the general public. The Division will insist that Echo Bay commit itself to compliance with the agreement and the NPDES permits. ~~and a requirement that Echo Bay Mining is party to the agreement~~

Long Term Liability. There were several statements in the proposal which deal with the release of long term liability. These matters will need to be dealt with individually. In some cases the Division may not have the authority to release SGC from liability, in others the amount of release that we feel comfortable with is directly related to other conditions of the agreement. These issues will need to be dealt with during the drafting of an agreement.

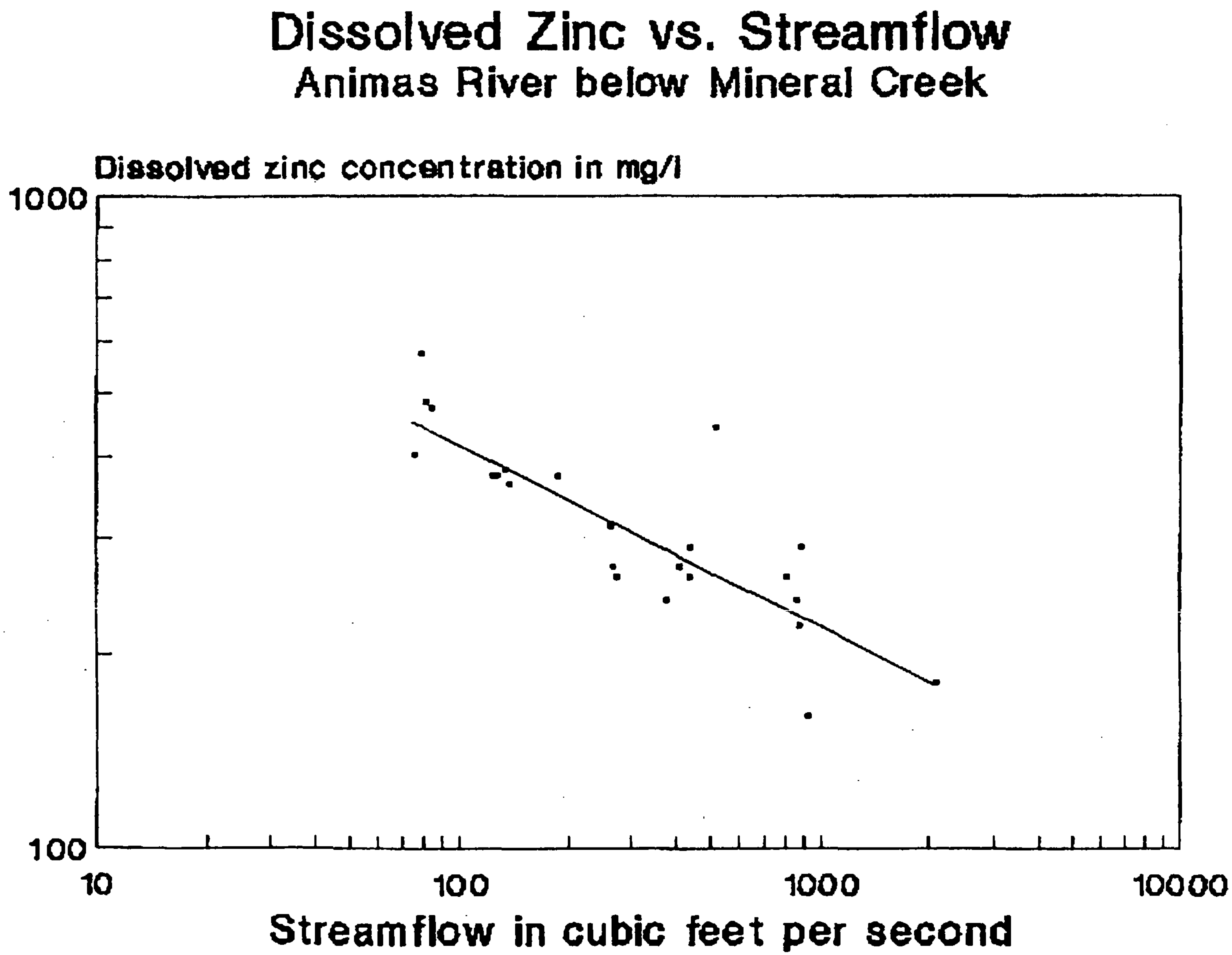
We hope that this letter provides you with information which will make our meeting on May 17 more efficient. Please contact me with any questions.

Sincerely,

Patricia Nelson

Patricia A. Nelson, P.E.
Industrial Program Chief
Permits and Enforcement Section
WATER QUALITY CONTROL DIVISION

cc: Jim Horn, Field Support Section, WQCD
MS-3 Permit File
Amelia Whiting, Attorney General's Office
Allen Sorenson, Division of Minerals and Geology
Bill Robb, Dufford and Brown, PC
David Holm, Water Quality Control Division



Dissolved Zinc vs. Streamflow
Animas River below Mineral Creek
Dissolved zinc concentration in mg/l
1000
100
10
100
1000
10000
Streamflow in cubic feet per second

SGC SCENARIOS

		AM.TUNNEL DISCHARGE (MGD)	AM.TUNNEL ZN CONC. (ug/l)	AM.TUNNEL ZN LOAD lb/day	CEMENT CK. ZN CONC. LOW		CEMENT CK ZN LOAD LOW		ANIMAS R. ZN CONC. LOW		ANIMAS R. LOAD LOW	
					LOW flow	HIGH flow	LOW	HIGH	LOW	HIGH	LOW	HIGH
1.	Maintain Present Conditions	2.2	300	5.5	1134	627	45	656	468	191	164	1798
									572	283	200	2590
2.	Bulkhead at SGC Property Bound.	1.23[a]	300	3.1	Am. Tunnel 13+3.1-5.5							
		.1-.5[b]	15.1 mg/L	13-63								
				11[e]	1247	689	50	721	585	290	205	2655
				61[e]	1644	908	66	951	630	315	221	2885
		.93[c]	2-6[d] mg/L	15-46								
				26[f]	1360	752	54	787	600	297	209	2721
				106	1984	1096	79	1147	669	336	234	3082
3.	Total Portal Bulkhead	2.2[c]	15.1 mg/L	272	2642	1460	106	1528	744	378	261	3462
		.1-.5	15.1 "	13-63								
				13	1247	689	50	721	585	290	205	2655
				63	1644	908	66	951	630	315	221	2885
		1.7-2.1	2-6 mg/L	40-160								
				40	1446	799	58	836	607	302	213	2770
				160	2438	1347	98	1410	720	365	252	3344

Broad Trough of 500ug/L

4. Terry Tunnel: Assume most Zn in Eureka Gu. is attributable to Terry Tunnel. Mine plug will reduce Zn levels in Animas River segment 3(a) 10% during high flow and 30% at low flow. This applies in both scenarios 2 and 3.

* Water Quality Standard for segment 4(a) just below Silverton 0.52 mg/l based upon ambient conditions

a Flow into American Tunnel beyond proposed property boundary bulkhead

b Flow through mine workings which discharges to Cement Ck following mine closure

- "If mine is "sealed" Co is not [illegible] for any point sources"
- Proposed point, non point source trade on #/day basis
- 1/4 MM gas capacity left [illegible] the tailings pond

* - Characterize & model wastes / streams underway by owner
- Suit brought against state by Company.
- WQC Comm. is to establish criteria on: segment 44 of Animas River; protect brown trout 225 ppb zinc; amb. 520 ppb zn below Silverton unless EPA promulgates own stnd.

(A) Maintain present cond [illegible] Gladstone - cement creek - so amb. stnd below Silverton will be maintained - S.J

Terry [illegible] Dick [illegible] for [illegible] zn load to upper Animas

(B) Set an instream stnd that they must meet, transients & long term

- MA & agreement (w) Echo Bay
- Legal consent agreement in mind
- WQ goal / model of WQ   Cement / Animas related WQ in Animas
- Current Animas WQ 520

- Touch base every 2 weeks (w) state

- TRADE off NPS vs POINT SOURCES IN SEALING MINE — RESULTED IN LAWSUIT
- TREATMENT OF Plugging ALTERNATIVES
- "Could be 25% BETTER"
- PRECEDENT 4 other sites
- TRADE ON PLUG. EXISTS IN CWA BUT NOT METALS
  re WHEREIMF/ZANDER — OK/NOT OK UNDER CWA
- where DO WE have Vulnerability
- DALE V. → FS → ?? APPROACH TO BASIN REMEDIATION, ANIMAS, ETC
  LEARN By Doing BEST APPROACH? PRIORITIZATION
  ALSO, Columbia RIVER BASIN
- PAUL — GREG P. ON SF INVOLVEMENT "$TAND-OFF!!" — PAUL
  SCORING 1ST. MELANIE — what about using the NATIONAL TOOLS
  MINING SITE GROUP? MUST 1ST ID APPROACH, TOOLS, ETC
  (1) MINING Co IS FUNDED TO DEMONSTRATE A SITE CLEANUP
- DALE V DEMO A BASIN LIKE ANIMAS AS A TEST BASE, PLAN, PRODUCTS
  , schedule using SF TOOLS
- mayflower mill — Purchaser is Wings — SAN JUAN COUNTY — Echo Bay
  WANTS TO "DONATE PROPERTY" BUT NOT IN DEMINIMIS — SO MARK
  ADVISES Echo Bay will be PRP (County Historical SOCIETY)
- SW ABND MINES — SW PERMITS
- NEXT MTG WED 12:30, 2ND WK, 14th of DEC.

File: SUNSYD11.304

Date: November 30, 1994

Subject: Colorado-EPA Review of Mine Owner Proposal to Seal Mine

ISSUES

Prior CNPDES permit/understandings/agreements?

Clean Water Act-compliance requirements?

Wastewater treatment effectiveness/lack thereof at altitude-background?

Aquatic toxicity test failure with treatment in place-resolution?

Incomplete data-company action?

Heresay data used-verification?

Lack of engineering detail-cross sections and need?

Lack of a water balance/metals balance-approach?

Metals/water (bypass?) release in proposed plan?

Closure/monitoring/wq action levels?

Bonding for possible future treatment?

Precedent setting decisions?

[c] "Natural flow" around mine workings discharging to Cement Ck

[d] "Background concentrations" of Zn in mineralized but unmined fractures

[e] best case loading from mine workings discharging to Cement Creek

[f] best case loading from mine workings and "natural" flow discharging to Cement Ck.

NOT GOALS, AMBIENT STNDARDS TO BE MET FOR 1ST 3 YEARS

Colorado Department of Public Health and Environment
WATER QUALITY CONTROL COMMISSION

M E M O R A N D U M

TO: Water Quality Control Division
Parties to the Animas River Basin Rulemaking
Other Interested Persons

FROM: Paul Frohardt, Administrator

DATE: November 22, 1994

SUBJECT: Draft Preliminary Final Action Documents

As many of you are aware, after extensive discussions at its November 14 and 15, 1994 meeting, the Commission voted to give preliminary final approval to a package of Animas River Basin water quality classification and standards revisions based on a hybrid approach that draws from competing proposals submitted in the rulemaking hearing. First, the set of proposals advanced by the Water Quality Control Division staff, based on the promulgation of underlying goal-based numerical and narrative standards for the critical segments, is adopted by the Commission with a three-year delayed effective date. The second component of the action being taken by the Commission is the adoption of ambient quality-based standards that will be in place for the critical segments until the effective date of the goal-based standards described above.

Although the general concept of this alternative package received unanimous support at the Commission's November meeting, the Commission's discussion did not resolve all of the details of the proposal. The Commission did provide general direction to prepare a draft of the hybrid proposal that is based on the Division's proposal as to the details not addressed by the Commission. The enclosed draft is based on this general direction.

The Commission has agreed to reopen the rulemaking record in this proceeding for the purpose of receiving comments from any interested persons on the enclosed draft proposal. The Commission will continue its deliberations regarding the issues raised in this hearing at its January 9 and 10, 1995 meeting in Denver. **In order to be considered by the Commission, written comments on the enclosed draft must be received in the Commission Office by 5:00 p.m., Wednesday, December 28, 1994.**

In order to facilitate review of the enclosed draft, please note the following instances in which potentially important details required judgment regarding the Commission's intent. Further comment on the issues associated with these details may be helpful to the Commission.

1. For segments 2, 3b, 7 and 8, a narrative ambient quality-based standard for all metals was inserted as the standard applicable for the next three years, since no numerical values for ambient quality for individual metals were submitted as part of the evidence.

2. For segments 4a, 4b and 9b, with one exception the ambient metals standards proposed by Sunnyside, along with additional table value standards proposed by the Division, were listed as the standards applicable for the next three years. For segment 4a, the Division's calculated ambient value has been listed as the ambient standard. It is assumed that the ambient standards proposed by Sunnyside for iron (Fe) are total recoverable values. The pH range proposed by the Division has been listed for segment 9b.

3. Section 3.1.7(1)(b)(ii) of the Basic Standards sets forth a policy that "in no case may an ambient chronic standard be more lenient than the acute standard." The evidence indicates some question as to whether the ambient standards proposed to be in place for the next three years for zinc for segment 4a and for zinc and copper for segment 9b avoid acute toxicity.

4. For segment 4a, the aquatic life cold class 2 classification and the use-protected designation proposed by Sunnyside have been listed as applicable for the next three years, since this classification and designation are arguably more consistent with the ambient standards applicable during that period. At the end of three years, the use-protected designation would expire and the aquatic life classification would become cold water class 1.

5. For segment 3a, since the Division and Sunnyside proposals are consistent as to the appropriate numerical standards, the class 1 aquatic life classification (and absence of a use-protected designation) proposed by the Division have been listed as immediately applicable, rather than incorporating the Sunnyside proposal for classification and designation now and having that change in three years even though no standards would change at that time.

6. For segment 9b, the currently applicable class 1 aquatic life classification has been left in place, even though ambient standards proposed by Sunnyside would be adopted for the next three years. The Commission's discussion focussed principally on standards rather than classifications, and leaving the class 1 classification in place may avoid a downgrading debate with EPA. The Division and the parties agreed that a use-protected designation should be adopted for this segment.

cc: Water Quality Control Commission

DRAFT COPY

REGION: 9 BASIN: ANIMAS AND FLORIDA RIVER Stream Segment Description	Desig	Classifications	NUMERIC STANDARDS PHYSICAL and BIOLOGICAL	INORGANIC mg/l		METALS ug/l			TEMPORARY MODIFICATIONS AND QUALIFIERS
1. All tributaries to the Animas River and Florida River, including all wetlands, lakes and reservoirs, which are within the Weminuche Wilderness Area.		Aq Life Cold 1 Recreation 1 Water Supply Agriculture	D.O. = 6.0 mg/l D.O. (sp)=7.0 mg/l pH = 6.5-9.0 F.Coli=200/100ml	NH_3(ac)=TVS NH_3(ch)=0.02 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 SO_4=250	As(ac)=50(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=300(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ch)=50(dis) ~~Mn(ch)=1000(Trec)~~ ~~Hg(ch)=0.01(Trec)~~ Hg(ch)=0.01(tot)	Ni(ac/ch)=TVS Se(ch)=10(Trec) Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac/ch)=TVS	
2. Mainstem of the Animas River, including all tributaries and wetlands, from the outlet of Denver Lake ~~source~~ to a point immediately above the confluence with Maggie Gulch, ~~Elk Creek,~~ except for specific listings in Segments 1 ~~and 5 through 8a and 8b~~.	UP	Recreation 2 Agriculture	~~pH = 6.5-9.0~~ pH = 5.8-9.0 ~~F.Coli=2000/100ml~~ F.Coli=200/100ml			Effective until March 2, 1998: Existing ambient quality for all metals: Effective as of March 2, 1998: The concentration of dissolved aluminum, cadmium, copper, iron, lead, manganese, and zinc that is directed toward maintaining and achieving water quality standards established for segments 3a, 4a, 4b, and 9b.			Temp mod effective for 3 years beginning 3/2/98: existing ambient quality for all metals.
3a. Mainstem of the Animas River, including wetlands, from a point immediately below the confluence with Maggie Gulch to immediately above the confluence with Cement Creek.		Aq Life Cold 1 Recreation 2 Agriculture	D.O. = 6.0 mg/l D.O. (sp)=7.0 mg/l pH = 6.5-9.0 F.Coli=200/100ml	NH_3(ac)=TVS NH_3(ch)=0.02 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75	Al(ac/ch)=TVS As(ac)=100(Trec) Cd(ac/ch)=1.7 CrIII(ac/ch)=TVS CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe=132(dis) Pb(ac/ch)=TVS Mn(ch)=1000 Hg(ch)=0.01(tot)	Se(ac/ch)=TVS Ni(ac/ch)=TVS Ag(ac)=TVS Zn(ac/ch)=640	
3b. ~~4.~~ Mainstem of the Animas River, including wetlands, from a point immediately above the confluence with Cement Creek ~~Junction Creek~~ to a point immediately above the confluence with Mineral Creek ~~the Colorado/New Mexico border~~.	UP	Recreation 2 ~~Water Supply~~ ~~Agriculture~~	~~D.O. = 6.0 mg/l~~ ~~D.O. (sp)=7.0 mg/l~~ ~~pH = 6.5-9.0~~ pH = 6.0-9.0 F.Coli=2000/100ml	~~NH_3(ac)=TVS~~ ~~NH_3(ch)=0.02~~ ~~Cl_2(ac)=0.019~~ ~~Cl_2(ch)=0.011~~ ~~CN=0.005~~	~~S=0.002~~ ~~B=0.75~~ ~~NO_3=10~~ ~~Cl=250~~ ~~SO_4=250~~	Effective until March 2, 1998: Existing ambient quality for all metals: Effective as of March 2, 1998: The concentration of dissolved aluminum, cadmium, copper, iron, lead, manganese, and zinc that is directed toward maintaining and achieving water quality standards established for segments 3a, 4a, 4b, and 9b.			~~All metals are Trec unless otherwise noted.~~ Temp mod effective for 3 years beginning 3/2/98: Zn(ch)=667
4a. Mainstem of the Animas River, including wetlands, from a point immediately above the confluence with Mineral Creek to the confluence with Elk Creek.	Eff until 3/2/98: UP	Recreation 1 Eff until 3/2/98 Aq Life Cold 2 Eff as of 3/2/98: Aq Life Cold 1*	D.O. = 6.0 mg/l D.O.(sp)=7.0 mg/l pH = 6.5-9.0 F.Coli=200/100ml	NH_3(ac)=TVS NH_3(ch)=0.02 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75	Al(ac/ch)=TVS As(ch)=100(Trec) Cd(ac/ch)=1.6 CrIII(ac/ch)=TVS CrVI(ac/ch)=TVS Effective until March 2, 1998: Fe(ch)=2000(Trec); Zn(ch)=820 Effective as of March 2, 1998: Fe(ch)=1000(Trec); Zn(ch)=225	Cu(ac/ch)=TVS Fe(ch)=300(dis) Pb(ac/ch)=TVS Mn(ch)=1000 Mn(ch)=1000	Hg(ch)=0.01(tot) Ni(ch)=TVS Se(ac/ch)=TVS Ag(ch)=TVS	Temp mod effective for 3 years beginning 3/2/98: Zn(ch)=820 *Goal

3b. Mainstem of the Animas River, including wetlands, from the confluence with Elk Creek to the confluence with Junction Creek.		Aq Life Cold 1 ~~Recreation 2~~ Recreation 1 Water Supply Agriculture	D.O. = 6.0 mg/l D.O.(sp)=7.0 mg/l pH = 6.5-9.0 ~~F.Coli=2000/100ml~~ F.Coli=200/100ml	NH_3(ac)=TVS NH_3(ch)=0.02 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 SO_4=250	As(ch)=50 As(ch)=100(Trec) Cd(ch)=1 Cd(ac)=TVS (tr) Cd(ch)=TVS CrIII(ch)=50 CrIII(ac/ch)=TVS CrVI(ac/ch)=TVS Cu(ch)=20 Cu(ac/ch)=TVS Effective until March 2, 1998: Zn(ch)=180 Effective as of March 2, 1998: Zn(ch)=TVS	Fe(ch)=300(dis) Fe(ch)=1160 Fe(ch)=1500(Trec) Pb(ch)=11 Pb(ac/ch)=TVS Mn(ch)=50(dis) Mn(ch)=1000 Mn(ch)=440 Hg(ch)=.05 Hg(ch)=0.01(tot)	Ni(ch)=60 Ni(ch)=TVS Se(ch)=10 Se(ac/ch)=TVS Ag(ch)=1 Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ch)=410	Temp mod effective for 3 years beginning 3/2/98: Zn(ch)=180
5a. Mainstem of the Animas River, including wetlands, to the Southern Ute Indian Reservation boundary. ~~from the confluence with Junction Creek to the Colorado/New Mexico border.~~		Aq Life Cold 1 ~~Recreation 2~~ Recreation 1 Water Supply Agriculture	D.O. = 6.0 mg/l D.O. (sp)=7.0 mg/l pH = 6.5-9.0 F.Coli=200/100ml	NH_3(ac)=TVS NH_3(ch)=0.02 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 SO_4=250	As(ch)=50 Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) ~~CrVI(ac)=50(Trec)~~ CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=300(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ch)=50(dis) Hg(ch)=0.01(tot) Ni(ch)=TVS	Se(ac/ch)=TVS Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac/ch)=TVS	
5b. Mainstem of the Animas River, including wetlands, from the Southern Ute Indian Reservation boundary ~~confluence with Junction Creek~~ to the Colorado/New Mexico border.		Aq Life Cold 1 ~~Recreation 2~~ Recreation 1 Water Supply Agriculture	D.O. = 6.0 mg/l D.O. (sp)=7.0 mg/l pH = 6.5-9.0 F.Coli=200/100ml	NH_3(ac)=TVS NH_3(ch)=0.02 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 SO_4=250	As(ch)=50 Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) ~~CrVI(ac)=50(Trec)~~ CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=300(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ch)=50(dis) Hg(ch)=0.01(tot) Ni(ch)=TVS	Se(ac/ch)=TVS Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac/ch)=TVS	
6b. Mainstem, including all tributaries, wetlands, lakes and reservoirs, of Cinnamon Creek, Grouse Creek, Picayne Gulch, Minnie Gulch, Maggie Gulch, Cunningham Creek, Boulder Creek, Whitehead Gulch, and Molas Creek from their sources to their confluences with the Animas River. Mainstem of the Animas from the source to the outlet of Denver Lake.		Aq Life Cold 1 Recreation 2 Water Supply Agriculture	D.O. = 6.0 mg/l D.O. (sp)=7.0 mg/l pH = 6.5-9.0 ~~F.Coli=2000/100ml~~ F.Coli=200/100ml	NH_3(ac)=TVS NH_3(ch)=0.02 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 SO_4=250	As(ac)=50(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=300(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ch)=50(dis) ~~Mn(ch)=1000(Trec)~~ ~~Hg(ch)=0.01(Trec)~~ Hg(ch)=0.01(tot)	Ni(ac/ch)=TVS Se(ch)=10(Trec) Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac/ch)=TVS	
7b. Mainstem of Cement Creek, including all tributaries, wetlands, lakes, and reservoirs, from the source to the confluence with the Animas River.	UP	Recreation 2 Agriculture	~~pH=6.5-9.0~~ pH = 3.7-9.0 ~~F.Coli=2000/100ml~~ F.Coli=200/100ml			Effective until March 2, 1998: Existing ambient quality for all metals. Effective as of March 2, 1998: The concentration of dissolved aluminum, cadmium, copper, iron, lead, manganese, and zinc that is directed toward maintaining and achieving water quality standards established for segments 3a, 4a, 4b, and 9b.			Temp mod effective for 3 years beginning 3/2/98: existing ambient quality for all metals.
8b. Mainstem of Mineral Creek, including all tributaries and wetlands, from the source to a point immediately above the confluence with South Mineral Creek except for the specific listing in Segment 9a 8a.	UP	Recreation 2 Agriculture	~~pH=3.5 - 9.0~~ pH = 4.8 - 9.0 ~~F.Coli=2000/100ml~~ F.Coli=200/100ml	~~CN=0.2~~	~~B=0.75~~	Effective until March 2, 1998: Existing ambient quality for all metals. Effective as of March 2, 1998: The concentration of dissolved aluminum, cadmium, copper, iron, lead, manganese, and zinc that is directed toward maintaining and achieving water quality standards established for segments 3a, 4a, 4b, and 9b.			~~All metals are Trec unless otherwise noted.~~ Temp mod effective for 3 years beginning 3/2/98: existing ambient quality for all metals.

DRAFT COPY

9a 8a. Mainstem of South Mineral Creek including all tributaries, wetlands, lakes and reservoirs from the source to a point immediately above the confluence with Mineral ~~Clear~~ Creek; mainstems, including all tributaries, wetlands, lakes and reservoirs of Mill Creek and Bear Creek from sources to confluence with Mineral Creek; all lakes and reservoirs in the drainage areas described in Segments 7 through 9.		Aq Life Cold 1 Recreation 2 Water Supply Agriculture	D.O. = 6.0 mg/l D.O. (sp)=7.0 mg/l pH = 6.5-9.0 F.Coli=200/100ml	NH_3(ac)=TVS NH_3(ch)=0.02 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 SO_4=250	As(ac)=50(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=300(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ch)=50(dis) ~~Mn(ch)=1000(Trec)~~ ~~Hg(ch)=0.01(Trec)~~ Hg(ch)=0.01(tot)	Ni(ac/ch)=TVS Se(ch)=10(Trec) Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac/ch)=TVS	
9b 8b. ~~Mainstem of South Mineral Creek, including all tributaries, from a point immediately above the confluence with Clear Creek to the confluence with Mineral Creek.~~ Mainstem of Mineral Creek, including wetlands, from immediately above the confluence with the South Fork to the confluence with the Animas River.	UP	Aq Life Cold 1 Recreation 2 Agriculture	D.O. = 6.0 mg/l D.O. (sp)=7.0 mg/l ~~F.Coli=2000/100ml~~ F.Coli=200/100ml Eff until 3/2/98: pH = 6.2 - 9.0 Eff as of 3/2/98: pH = 6.5 - 9.0	NH_3(ac)=TVS NH_3(ch)=0.02 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05	Al(ac/ch)=TVS ~~As(ch)=50~~ As(ch)=100(Trec) ~~Cd(ch)=2~~ Cd(ac)=TVS(tr) ~~CrIII(ch)=100~~ CrIII(ac/ch)=TVS Effective until March 2, 1998: Cd(ch)=1.7 Zn(ch)=544 Effective as of March 2, 1998: Cd(ch)=TVS Zn(ch)=TVS	~~CrVI(ch)=25~~ CrVI(ac/ch)=TVS Cu(ac)=TVS ~~Fe(ch)=1000~~ Pb(ac/ch)=TVS14 Mn(ch)=1000 ~~Hg(ch)=.05~~ Cu(ch)=57 Cu(ch)=TVS	Hg(ch)=0.01(tot) Ni(ac/ch)=TVS ~~Se(ch)=20~~ Se(ac/ch)=TVS Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac)=TVS Fe(ch)=5515(Trec) Fe(ch)=1000(Trec)	~~All metals are Trec unless otherwise noted.~~ Temp mod: effective for 3 years beginning 3/2/98: pH=6.2-9.0 Cu=62 Fe=3416(dis) Zn=644

REGION: 9 BASIN: ANIMAS AND FLORIDA RIVER Stream Segment Description	Desig	Classifications	NUMERIC STANDARDS PHYSICAL and BIOLOGICAL	INORGANIC mg/l		METALS ug/l			TEMPORARY MODIFICATIONS AND QUALIFIERS
10. Mainstem of the Florida River from the boundary of the Weminuche Wilderness Area to the Florida Farmers Canal Headgate, except for the specific listings in Segment 12b.		Aq Life Cold 1 Recreation 1 Water Supply Agriculture	D.O.=6.0 mg/l D.O.= 7.0 mg/l pH = 6.5-9.0 F.Coli=200/100ml	NH_3(ac)=TVS NH_3(ch)=0.02 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 SO_4=250	As(ac)=50(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/cu)=TVS	Fe(ch)=300(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ch)=50(dis) Mn(ch)=1000(Trec) ~~Hg(ch)=0.01(Trec)~~ Hg(ch)=0.01(tot)	Ni(ac/ch)=TVS Se(ch)=10(Trec) Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac/ch)=TVS	
11. Mainstem of the Florida River from the Florida Farmers Canal Headgate to the confluence with the Animas River.		Aq Life Cold 1 Recreation 1 Water Supply Agriculture	D.O. = 6.0 mg/l D.O.(sp)=7.0 mg/l pH = 6.5-9.0 F.Coli=200/100ml	NH_3(ac)=TVS NH_3(ch)=0.02 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 SO_4=250	As(ac)=50(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=300(dis) Fe(ch)=1000(Trec Pb(ac/ch)=TVS Mn(ch)=50(dis) Mn(ch)=1000(Trec) ~~Hg(ch)=0.01(Trec)~~ Hg(ch)=0.01(tot)	Ni(ac/ch)=TVS Se(ch)=10(Trec) Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac/ch)=TVS	
12a. All tributaries to the Animas River, including all lakes and reservoirs from a point immediately above the confluence with Elk Cr. to a point immediately below the confluence with Hermosa Cr. except for specific listings in Segment 15. All tributaries to the Florida River including all lakes and reservoirs from the source to the outlet of Lemon Reservoir except the specific listing in Segment 1. Mainstems of Red and Shearer Creeks from their sources to their confluences with the Florida River.		Aq Life Cold 1 Recreation 1 Water Supply Agriculture	D.O. = 6.0 mg/l D.O. (sp)=7.0 mg/l pH = 6.5-9.0 F.Coli=200/100ml	NH_3(ac)=TVS NH_3(ch)=0.02 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 SO_4=250	As(ac)=50(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=300(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ch)=50(dis) Mn(ch)=1000(Trec) ~~Hg(ch)=0.01(Trec)~~ Hg(ch)=0.01(tot)	Ni(ac/ch)=TVS Se(ch)=10(Trec) Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac/ch)=TVS	

**SEE STATEMENT OF BASIS AND PURPOSE

DRAFT COPY

12a. All tributaries to the Animas River, including all lakes and reservoirs from a point immediately above the confluence with Elk Cr. to a point immediately below the confluence with Hermosa Cr. except for specific listings in Segment 15. All tributaries to the Florida River including all lakes and reservoirs from the source to the outlet of Lemon Reservoir except the specific listing in Segment 1. Mainstems of Red and Shearer Creeks from their sources to their confluences with the Florida River.		Aq Life Cold 1 Recreation 1 Water Supply Agriculture	D.O. = 6.0 mg/l D.O. (sp)=7.0 mg/l pH = 6.5-9.0 F.Coli=200/100ml	NH_3(ac)=TVS NH_3(ch)=0.02 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 SO_4=250	As(ac)=50(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=300(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ch)=50(dis) Mn(ch)=1000(Trec) ~~Hg(ch)=0.01(Trec)~~ Hg(ch)=0.01(tot)	Ni(ac/ch)=TVS Se(ch)=10(Trec) Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac/ch)=TVS	
12b. Lemon Reservoir.		Aq Life Cold 1 Recreation 1 Water Supply Agriculture	D.O. = 6.0 mg/l D.O. (sp)=7.0 mg/l pH = 6.5-9.0 F.Coli=200/100ml	NH_3(ac)=TVS NH_3(ch)=0.02 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10.02 Cl=250 SO_4=250	As(ac)=50(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=300(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ch)=50(dis) Mn(ch)=1000(Trec) ~~Hg(ch)=0.01(Trec)~~ Hg(ch)=0.01(tot)	Ni(ac/ch)=TVS Se(ch)=10(Trec) Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac/ch)=TVS	
13a. Mainstem of Junction Creek, and including all tributaries, from U.S. Forest Boundary to confluence with Animas River.	UP	Aq Life Cold 2 Recreation 2 Agriculture	D.O.=6.0 mg/l D.O.(sp)=7.0 mg/l pH = 6.5-9.0 F.Coli=2000/100ml	NH_3(ac)=TVS NH_3(ch)=0.02 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05	As(ch)=50(Trec) ~~As(ac/ch)=TVS~~ Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac/ch)=TVS CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=1000(Trec) Pb(ac/ch)=TVS Mn(ch)=1000(Trec) ~~Hg(ch)=0.01(Trec)~~ Hg(ch)=0.01(tot) Ni(ac/ch)=TVS Se(ac/ch)=TVS	Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac/ch)=TVS	
13b. All tributaries to the Animas River, including all lakes and reservoirs, from a point immediately below the confluence with Hermosa Creek to the ~~Colorado/New Mexico border.~~ Southern Ute Indian Reservation boundary except for the specific listings in Segments 10, 11, 12a, 12b, 13a and 14; all tributaries to the Florida River, including all lakes and reservoirs, from the outlet of Lemon Reservoir to the confluence with the Animas River, except for specific listings in Segment 12a.	UP	Aq Life Cold 2 Recreation 2 Agriculture	D.O. - 6.0 mg/l D.O.(sp)=7.0 mg/l pH = 6.5-9.0 F.Coli=2000/100ml						
13c. All tributaries to the Animas River, including all lakes and reservoirs, from the Southern Ute Indian Reservation boundary ~~a point immediately below the confluence with Hermosa Creek~~ to the Colorado/New Mexico border, except for the specific listings in Segments 10, 11, 12a, 12b, 13a and 14; all tributaries to the Florida River, including all lakes and reservoirs, from the outlet of Lemon Reservoir to the confluence with the Animas River, except for specific listings in Segment 12a.	UP	Aq Life Cold 2 Recreation 2 Agriculture	D.O. - 6.0 mg/l D.O.(sp)=7.0 mg/l pH = 6.5-9.0 F.Coli=2000/100ml						

**SEE STATEMENT OF BASIS AND PURPOSE

DRAFT COPY

REGION: 9 BASIN: ANIMAS AND FLORIDA RIVER Stream Segment Description	Desig	Classifications	NUMERIC STANDARDS: PHYSICAL and BIOLOGICAL	INORGANIC mg/l		METALS ug/l			TEMPORARY MODIFICATIONS AND QUALIFIERS
14. Mainstem of Lightner Creek from the source to the confluence with the Animas River.		Aq Life Cold 1 Recreation 1 Water Supply Agriculture	D.O. = 6.0 mg/l D.O. (sp)=7.0 mg/l pH = 6.5-9.0 F.Coli=200/100ml	NH_3(ac)=TVS NH_3(ch)=0.02 Cl_2(ac)=0.019 Cl_2(ch)=0.011 CN=0.005	S=0.002 B=0.75 NO_2=0.05 NO_3=10 Cl=250 SO_4=250	As(ac)=50(Trec) Cd(ac)=TVS(tr) Cd(ch)=TVS CrIII(ac)=50(Trec) CrVI(ac/ch)=TVS Cu(ac/ch)=TVS	Fe(ch)=300(dis) Fe(ch)=1000(Trec) Pb(ac/ch)=TVS MN(ch)=50(dis) Mn(ch)=1000(Trec) ~~Hg(ch)=0.01(Trec)~~ Hg(ch)=0.01(tot)	Ni(ac/ch)=TVS Se(ch)=10(Trec) Ag(ac)=TVS Ag(ch)=TVS(tr) Zn(ac/ch)=TVS	
15. Mainstem of Purgatory Creek from source to Cascade, Cascade Creek, Soulding Creek from the source to Elbert Creek, and Nary Draw from the source to Naviland Lake.	UP	Aq Life Cold 2 Recreation 2 Water Supply Agriculture	D.O.=6.0 mg/l D.O.(sp)=7.0 mg/l pH = 6.5-9.0 F.Coli=2000/100ml	CN=0.2 S=0.05 NO_2=1.0	NO_3=10 Cl=250 SO_4=250	As(ch)=50 Cd(ch)=10 CrIII(ch)=50 CrVI(ch)=50	Cu(ch)=1000 Fe(ch)=0.3(dis) Pb(ch)=50 Mn(ch)=50	Hg(ch)=2(tot) Se(ch)=10 Ag(ch)=50 Zn(ch)=5000	All metals are Trec unless otherwise noted.

**SEE STATEMENT OF BASIS AND PURPOSE

DRAFT COPY

3.4.15 STATEMENT OF BASIS, SPECIFIC STATUTORY AUTHORITY, AND PURPOSE; SEPTEMBER 12, 1994 HEARING:

The provisions of 25-8-202(1)(a), (b) and (2); 25-8-203; 25-8-204; and 25-8-402 C.R.S. provide the specific statutory authority for adoption of these regulatory amendments. The Commission also adopted in compliance with 24-4-103(4), C.R.S., the following statement of basis and purpose.

BASIS AND PURPOSE

A. BACKGROUND

Between 1991 and 1993 the Water Quality Control Division, in cooperation with several federal, state, local and private interests conducted an intensive water quality investigation of the Animas River and its tributaries from Elk Creek to the headwaters. The objectives of the study were to characterize the current chemical, biological, and physical conditions of the Animas River and selected tributaries above Elk Creek and to quantify the areas of highest metal loadings and determine the potential for water quality improvement sufficient to allow naturally reproducing trout populations; and to prioritize sites for remedial projects based on relative loading, environmental impact, feasibility, cost, and benefits.

The water quality of this area is extensively impacted by heavy metals which are attributed to both natural and anthropogenic factors. The results of the investigation have been used to identify the beneficial uses and water quality that are currently being achieved or that may reasonably be achieved within a twenty year period through restoration of disturbed sites.

B. OVERVIEW

The starting point for the Commission's analysis is a conclusion that appears to be shared by most, if not all, of the participants in this rulemaking proceeding: current water quality in the Animas River Basin can and should be improved. For example, quoting from the Statement of the Animas River Stakeholders' Group:

> All stakeholders agree that current water quality can and should be protected from any further degradation; all agree that there are opportunities to make improvements, and that improvement is desirable even if it were not mandated; all agree that the task before us now is to identify the sources of significant human-caused loadings and find ways to remediate them.

Beyond this starting point, there was considerable debate in the hearing, and among Commission members in its initial deliberations, regarding the most appropriate and constructive way to encourage and stimulate the desired water quality improvement. One perspective offered was that the Commission should adopt underlying numerical and narrative standards for the critical segments in question that would establish goals for water quality improvement, tempered by temporary modifications that recognize current water quality. An alternative perspective suggested that adopting such goals as legally effective standards before the feasibility of specific clean-up projects had been determined--and the achievable improvement quantified--may hinder the cooperative, community-based effort that has been evolving to identify, prioritize and acquire funding for remediation projects.

Following extensive discussion and debate, the Commission has decided to adopt a hybrid result that consists of two components. First, the set of proposals advanced by the Water Quality Control Division staff, based on the promulgation of underlying goal-based numerical and narrative standards for the critical segments, is adopted by the Commission with a three-year delayed effective date. The Commission finds that the evidence submitted in the hearing provides a sound scientific basis for the adoption of the Division's proposal, with the caveat that three-year temporary modifications almost certainly will not provide an adequate period in which to achieve water quality improvement that will attain the underlying standards. The issue of temporary modifications is discussed further below.

The second component of the action being taken by the Commission is the adoption of ambient quality-based standards that will be in place for the critical segments until the effective date of the goal-based standards described above. The purpose of taking this step, as opposed to adopting the goal-based standards with an immediate effective date, is to encourage the cooperative, community-based effort toward water quality improvement that has begun in the basin, unencumbered by the potential implications of the goal-based standards being in effect. This action is an experiment, intended to assess the ability of a cooperative process to achieve meaningful progress toward water quality improvement without the underlying improvement goal being reflected in currently effective, legally binding water quality standards.

If substantial progress toward water quality improvement--through the identification, prioritization and implementation of remediation projects--is achieved within the next three years, and if it appears three years from now that the lack of legal effectiveness of the goal-based standards will provide the best stimulus for further progress, further delay in the effective date of the goal-based standards can be considered by the Commission at that time. Of course, such progress could also demonstrate that the identified goals are achievable, or that they should be refined in some manner.

If, however, substantial and diligent progress toward water quality improvement is not achieved over the next three years, it is the intent of the Commission that the goal-based standards should and will be allowed to go into effect at that time to stimulate further progress. In a new rulemaking hearing, the burden should be on those that have argued that clean-up will be more successful with a cooperative effort working toward a goal, without that goal being reflected in currently effective water quality standards, to demonstrate the success of this experiment.

The Water Quality Control Commission expects that the cooperative effort will be successful and is attempting by this action to send that message to all stakeholders. To those concerned about the potential impacts on property owners of goal-based standards being in effect, the message is that the Commission wants to encourage this locally-driven, cooperative watershed improvement initiative by demonstrating as much flexibility as possible. To federal agencies or others with potential resources to devote to water quality improvement efforts, the message is that working toward such improvement in this basin is an extremely high priority for the State of Colorado. To the Water Quality Control Division and those that supported their proposal in this rulemaking proceeding, the message is that the Commission has been persuaded--based on the unprecedented level of monitoring and analysis that has occurred in this basin--that a sound scientific justification has been provided for the adoption of goal-based water quality standards, and that these standards should be allowed to go into effect unless it is demonstrated that the pending experiment in cooperative watershed management can succeed without this legal impetus. To all of the residents of the Animas River Basin, the message is that the Commission is concerned about water quality in your basin and is willing to work with you to explore whatever options appear most likely to facilitate progress toward water quality improvement in the least disruptive and most expeditious manner.

In summary, the Commission's action in revising the Animas River Basin water quality classifications and standards should in no way be interpreted as a sanctioning of the status quo. To repeat, current water quality in the Animas River Basin can and should be improved. The purpose of the Commission's action is to establish a clear goal of attaining such improvement, while providing regulatory flexibility intended to encourage cooperative efforts toward such improvement.

C. IMPLICATIONS OF THE HYBRID ACTION

Because of the unorthodox nature of the hybrid action being taken, the Commission believes that it may be important to clarify its understanding regarding the implications of this action for various activities or decisions that will need to be undertaken by others during the next three years.

For any existing point source discharge permit that may come up for renewal during the next three years, or for any new wastewater discharge permit issued during this period, the Commission intends that the permit would be written based on the ambient quality-based standards then in effect, along with other applicable effluent quality restrictions. The Commission also understands that ambient quality-based standards would require the continuation of current treatment levels for permit renewals, to assure that further degradation of water quality does not occur.

To the extent that general or individual storm water permits may be required for some sites in the basin, the Commission understands that the water quality standards now being adopted are not likely to affect the content of the first round of any such permits, which are anticipated to be based principally on the implementation of best management practices (BMPs). Such initial BMPs are not likely to be significantly different whether they are deemed to be technology-based or water quality-based.

Finally, as discussed above, the Commission intends this action to provide a clear message to other agencies, entities and persons involved with potential nonpoint source clean-up projects that the Animas River Basin is in fact a high priority for such efforts. The delayed effective date for goal-based standards should not be interpreted to in any way lessen the priority of this basin; rather, as discussed above, this hybrid action is intended to provide flexibility for the cooperative, community-based efforts toward clean-up while at the same time clarifying that improvement is the goal.

D. DELAYED CLASSIFICATIONS AND STANDARDS

This portion of this statement describes the basis for the goal-based standards that are scheduled to go into effect three years after the effective date of this action.

The upper Animas water quality study found that the Animas River and several tributaries above Maggie Gulch (segment 2), the Animas River from Cement Creek to Mineral Creek (segment 3b), Cement Creek and its tributaries (segment 7), and Mineral Creek above the confluence with South Mineral Creek (segment 8) do not support diverse forms of aquatic life owing to poor water quality and limited physical habitat. The imposition of effluent limits required under the Federal Act for point sources and cost-effective and reasonable best management practices (BMP's) for nonpoint sources are not likely to lead to the establishment of aquatic life in these segments. Additionally, federal regulation (40 C.F.R. 131.10) allows excluding an aquatic life classification where naturally occurring pollutant concentrations prevent the attainment of the use and/or human caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place. Therefore, an aquatic life classification is not being adopted for these segments. Downstream use classifications, however, depend on maintaining or improving the water quality in these segments. The

Commission has therefore, determined that narrative standards for metals based on the application of BMP's to nonpoint sources and the continuation of current treatment levels for existing point sources for these segments establish an appropriate goal for water quality in these segments. Narrative (and for zinc in segment 3b, numerical) temporary modifications have been adopted based on current ambient quality in these segments, to assure no additional degradation of downstream segments.

The Commission recognizes that even with aggressive clean-up efforts, it may take many years to achieve in-stream quality that attains the underlying goal-based standards. Three-year temporary modifications are being adopted in an attempt to avoid conflict with the current EPA policy that temporary modifications are variances that can not be extend for longer than three years without being readopted. The Commission anticipates that many, if not all, of the temporary modifications being adopted in this proceeding will need to be extended beyond three years to attain the underlying standards, even considering the delayed effective date of that portion of the action that includes temporary modifications.

The Commission has further determined that the Animas River between Maggie Gulch and Cement Creek (segment 3a) supports a population of brook trout that appears to be naturally reproducing in that it consists of multiple age classes. The segment also contains a diversity of macrobenthos and possesses physical habitat similar to other streams in the Southern Rocky Mountain ecoregion. Although the concentration of several metals, especially cadmium and zinc, are higher than what is required to protect the most sensitive aquatic life species, they are lower than the chronic toxic criteria for brook trout. Therefore a cold water aquatic life class 1 classification is being established to protect the resident aquatic life found in this segment. Ambient standards for cadmium and zinc are adopted to ensure that downstream use classifications and standards are not jeopardized. The imposition of effluent limits required under the Federal Act for point sources and cost-effective and reasonable best management practices for nonpoint sources are not likely to lead to the establishment of the most sensitive aquatic life species in this segment. However, consistent with its prior practice, the Commission has determined that the <u>most</u> sensitive species need not be present to find that a segment is "capable of sustaining a wide variety of cold water biota, including sensitive species", warranting a cold water class 1 classification. Section 3.1.7(1)(b)(ii) authorizes ambient standards where natural or irreversible man-induced ambient levels are higher than TVS but are adequate to protect the classified uses.

Mineral Creek between South Mineral Creek and the Animas River, renumbered segment 9b, was already classified aquatic life cold water class 1, with total recoverable table value standards. The upper Animas water quality study showed that pH, aluminum, copper, iron, and zinc greatly exceed TVS in this segment and that both fish and macroinvertebrates are absent from the segment. The physical habitat assessment, however, found it comparable to other habitats within the Southern Rocky Mountain ecoregion. Because most of the aluminum, copper, iron, and zinc are contributed from two areas, there may be a potential to reduce loading from either or both of these areas. The Commission chose not to remove the aquatic life classification until it has been demonstrated that sources cannot be remedied within a twenty year period or would cause more environmental damage than to leave it in place. The Commission adopted TVS for segment 9b, together with temporary modifications for aluminum, copper, iron, and zinc based on ambient quality until the feasibility of remediation has been established. A use-protected designation has been added to this segment based on four key parameters with existing quality worse than table values.

The Animas River between Mineral Creek and Elk Creek, renumbered segment 4a, has not previously had an aquatic life classification. The upper Animas water quality study found that the water quality below Mineral Creek is suitable for brook trout and has physical habitat similar to other aquatic life streams in the Southern Rocky Mountain ecoregion. Some improvement in water quality from Cement Creek, Mineral Creek, and/or the Upper Animas may enable the water quality of the segment to support brown trout. However, the imposition of effluent limits required under the Federal Act for point sources and cost-effective and reasonable best management practices for nonpoint sources are not likely to lead to the establishment of aquatic life uses including the most sensitive species in this segment. The Commission adopted the aquatic life cold class 1 classification as a goal and TVS for this segment, except for the zinc standard which is based on the chronic toxic criterion for brown trout. Consistent with its prior practice, the Commission has determined that the <u>most</u> sensitive species need not be present or attainable to find that a segment is or may become "capable of sustaining a wide variety of cold water biota, including sensitive species", warranting a cold water class 1 classification. A temporary modification for zinc, based on the ambient quality, has been adopted until the feasibility for load reduction has been established.

E. AMBIENT QUALITY-BASED STANDARDS

This portion of this statement describes the basis for the ambient quality-based standards that are adopted for the three-year period starting with the effective date of this action.

For segments 2, 3b, 7 and 8, the Commission has adopted a narrative standard based on existing ambient quality for all metals to be applicable for the next three years. For segments 4a, 4b, and 9b, for this same time period the Commission has adopted ambient-quality based numerical standards for specific metals for which ambient quality currently is higher (worse than) table values. These standards are intended to protect the aquatic life that is currently in place in these segments until the goal-based standards go into effect. As discussed above, the primary basis for adopting these numerical and narrative ambient quality-based standards is to provide maximum regulatory flexibility to encourage the cooperative, community-based effort toward clean-up to proceed. This approach provides time in which additional information can be developed regarding the feasibility of specific remedial efforts that will result in water quality improvement.

Having ambient standards in place for the next three years means that any point source permits issued or renewed during this period will be based on those ambient standards, along with other applicable effluent quality restrictions, rather than being based on the more stringent goal-based standards. At the same time, the ambient standards should help assure that no additional degradation in water quality occurs for these segments in the next three years while clean-up actions are being examined and initiated.

For segment 4a, the aquatic life cold class 2 classification and the use-protected designation proposed by Sunnyside have been adopted for the next three years, since this classification and designation appear to be more consistent with the ambient standards applicable during that period. As discussed above, at the end of three years the use-protected designation would expire and the aquatic life classification would become cold water class 1.

For segment 9b, the currently applicable class 1 aquatic life classification has been left in place, even though ambient standards proposed by Sunnyside have been adopted for the next three years. The Commission believes that a downgrading of the classification of this segment is premature, pending additional analysis of clean-up opportunities. As noted above, the use-protected designation proposed by the Division and several parties has also been adopted.

F. OTHER ISSUES

The above discussion, like the evidence submitted at the hearing, focuses principally on appropriate aquatic life classifications and associated water quality standards. In this hearing the Commission also added an agriculture classification to segments 2, 3a, and 7, based on evidence regarding the presence of grazing. In addition, the Commission changed the recreation classification from class 2 to class 1 for segments 4a, 4b, 5a, and 5b, based on evidence regarding the presence of primary contact recreation. Finally, fecal coliform standards for segments 2 and 3a were changed from 2,000 to 200/ml, to provide additional protection that better reflects current ambient conditions. There are no affected point sources on these segments.

NPDES GENERAL PERMIT FOR ABANDONED MINES

- Final storm water regulations (Nov 1990) included inactive mines in realm of activities requiring storm water permits.

- NPDES permits are generally issued to the operator. Where there is no operator the land owner is responsible for applying for and complying with the permit. In many instances the land owner is the federal government (e.g. BLM, Forest Service).

- In 1991 EPA recognized that the current general permit structure is not well suited to inactive mines on federal land. The main reasons are: a) general permits require separate applications for each site; and b) general permits require action at each site concurrently.

- In August 1991 EPA published draft storm water general permits for the majority of storm water discharges covered under the rule.

  Based on OMB, DOI, and USDA concerns this draft excluded storm water discharges from inactive mining, inactive landfills, and inactive oil and gas operations on federal lands where an operator cannot be identified.

- EPA agreed to develop a general storm water permit specifically for inactive sites on federal lands where EPA maintains permitting authority.

- EPA circulated a draft "strawman" general permit in August 1991.

OPTIONS FOR REQUIREMENTS UNDER NPDES GENERAL PERMIT FOR POINT SOURCE DISCHARGES FROM INACTIVE MINING, OIL AND GAS, OR LANDFILL OPERATIONS ON FEDERAL LANDS

OPTION 1: COMPILE EXISTING INFORMATION AND GATHER NEW MONITORING DATA BEFORE SETTING PRIORITIES

AFTER 12 MONTHS: COMPILE EXISTING INFORMATION | DEVELOP MONITORING PLAN FOR AREAS WITH INSUFFICIENT DATA

AFTER 24 MONTHS: BASED ON OLD AND NEW DATA, RANK AREAS

AFTER T-1 MONTHS: CHARACTERIZATION OF HIGH RANKING AREAS

AFTER T-2 MONTHS: HAVE SITE PLANS FOR MITIGATION

OPTIONS FOR REQUIREMENTS UNDER NPDES GENERAL PERMIT FOR POINT SOURCE DISCHARGES FROM INACTIVE MINING, OIL AND GAS, OR LANDFILL OPERATIONS ON FEDERAL LANDS

OPTION 2: ADVANCE INITIALLY TO SITES WHERE DATA/BEST PROFESSIONAL JUDGEMENT INDICATE CLEAR BENEFITS OF MITIGATION

TWO TRACKS

UNIVERSE OF SITES

	FAST TRACK	SLOW TRACK
AFTER 6 MONTHS:	GATHER EXISTING INFO/ BPJ ANALYSIS	GATHER EXISTING INFO
AFTER 12 MONTHS:	CHARACTERIZATION OF HIGH RANKING AREAS	DEVELOP MONITORING PLAN (INCLUDING MONITORING PRIORITIES)
AFTER 24 MONTHS:	HAVE SITE PLANS FOR MITIGATION	
AFTER 36 MONTHS:	MITIGATION COMPLETED	BASED ON MONITORING, RANK AREAS
AFTER 48 MONTHS:		CHARACTERIZATION OF HIGH RANKING AREAS
AFTER 60 MONTHS:		HAVE SITE PLANS FOR MITIGATION

FLOW CHART OF PROPOSED REQUIREMENTS
FOR
NPDES GENERAL PERMIT FOR
INACTIVE MINING, OIL AND GAS, OR LANDFILL OPERATIONS
ON FEDERAL LANDS

After 12 Months: Identification of Receiving Waters, Impacts and Inactive Areas:

- Information Collection:
  - list receiving waters, designated uses, wq standards;
  - list known inactive operations;
  - list high value areas: ecological, human health, other;
  - list of known or suspected impaired waters and their impacts.

- Monitoring Plan for Areas with Insufficient Data.

After 24 Months: Ranking of Impaired Areas:

- Data Obtained From Monitoring Plan Proposed In 1st Year;

- List Impaired Water Bodies In Order of Highest Priority for Intensive, Site-Specific Characterization.

After 36 Months: Impaired Area Characterization:

- Characterize Highest Priorities Identified Above. Includes:
  - site description (activities and materials at site, visible structures, etc.);
  - identify pollutants (based on current and new monitoring);
  - identify sources of pollutants;
  - identify areas of high ecological value.

- Schedule for Additional Impaired Area Characterizations.

After 48 Months: Site Plans for Mitigation and/or Reclamation:

- Submittal of Site Plan To Include:
  - drainage map of sources in water body;
  - drainage patterns of sources with estimates of pollutant contribution;
  - all sampling data;
  - proposed management controls:
    - Sediment and Erosion
    - Runoff
    - Other Point Sources
  - site evaluation plan;
  - cost estimates.

SIMON HYDRO-SEARCH

5250 South Virginia Street
Suite 280
Reno, NV 89502

Telephone (702) 829-1200
(800) 347-4937
Facsimile (702) 829-1243

Preliminary Characterization of the Hydrology and Water Chemistry of the Sunnyside Mine and Vicinity, San Juan County, Colorado

February 11, 1992

Prepared for:

San Juan County Mining Venture
Washington Mining Company - Operator
P.O. Box 177
Silverton, Colorado 81433

Prepared by:

Simon Hydro-Search
5250 South Virginia, Suite 280
Reno, Nevada 89502

(702) 829-1200
(800) 347-4937

Mark D. Stock
Senior Hydrogeologist
Project Manager

Bob Walston
Hydrogeologist, P.E.

sanjuan\sunny\110361\oct91.Rpt

TABLE OF CONTENTS

SECTION PAGE

TABLE OF CONTENTS Con't

APPENDICES

1.0 EXECUTIVE SUMMARY

The Sunnyside Mine is located approximately 8 miles north of Silverton in northernmost San Juan County, Colorado. Slightly acidic water containing mobilized heavy metals flows out of both access tunnels to the mine. The purpose of this report is to present a conceptual hydrologic model of the mine vicinity so that the San Juan County Mining Venture (SJCMV) may be able to devise a long term plan which will allow a return to an approximation of pre-mine hydrologic conditions.

Ground water in the bedrock flow system in the vicinity of the Sunnyside Mine is transmitted via fracture permeability. The pre-mining static water level in the bedrock flow system beneath Sunnyside Basin is estimated to have been at an elevation of approximately 11,500 feet above mean sea level based on the water level in the Sunnyside Mine after almost 20 years of inactivity. The majority of flow in the deep ground-water system moved southwest from the Sunnyside Basin to discharge within the Cement Creek watershed. This ground water passed through fractures in rocks containing large quantities of metal sulfides-both along highly mineralized fractures and disseminated throughout the rock. The dissolved metals content of the ground water generally increased downgradient within the ground-water flow system. In the vicinity of Cement Creek springs derived from ground water which had traversed the deep flow system are estimated to have had a pH of less than 5.0 and elevated concentrations of lead, zinc, cadmium, manganese and iron. The chemistry of the base flows of area creeks would have been similar to the chemistry of the springs supplying that base flow. The average flows of area creeks would be augmented by surface runoff of differing chemistry. However, many surface drainages pass over sulfide-bearing rocks and some have a pH as low as 4.4.

The permeability characteristics of the majority of the ground-water flow system have not been affected by the excavation of the underground workings of the Sunnyside Mine. Dewatering of the mine has reduced the hydraulic head by about 850 feet and locally induced a ground-water gradient toward the underground workings. Most ground water entering the underground workings flows out of the American Tunnel; in effect taking a faster flow path to the Cement Creek watershed than it would have had under natural gradients.

Flow from the American Tunnel portal (at the lowest level of the mine) was measured at 3.1 million gallons per day (mgd) in October of 1991. In the deeper parts of the American Tunnel (farther than approximately 2500 feet from the portal) the majority of water transmitted to the tunnel originates from a few major fracture zones. Minor joints transmit a significant amount of water only in the first 2500 feet of the tunnel. More than half of the discharge of the American Tunnel enters the tunnel downstream of the SJCMV property line.

A large percentage of the surface water from the head of Eureka Gulch drains into the underground workings of the Sunnyside Mine via the Lake Emma Hole and other locations where workings intersect the land surface. The majority of the surface water entering the mine drains to Eureka Gulch via the Terry Tunnel (approximately 900 feet above the level of the

American Tunnel). Measured flow from the Terry Tunnel now varies from 82 gpm in autumn to at least 1400 gpm during spring runoff.

Drainage from both the American Tunnel and the Terry Tunnel is slightly acidic and contains elevated concentrations of metals. Although some of the metals content of the discharge from the American Tunnel is the result of sulfides exposed within the underground workings, much of the dissolved metals load is due to the natural metals content of ground water entering the tunnel. Much of the total metals content in the American Tunnel discharge originates from water entering the tunnel downstream of the SJCMV property line. Most, but not all, of the acid and metals content of drainage from the Terry Tunnel is a direct result of surface water reacting with sulfides exposed by mining.

Drainage from both access tunnels is presently being treated with lime which both increases the pH and precipitates heavy metals. The resulting sludge is transported in tanker trucks to the tailings facility near the Mayflower Mill.

2.0 INTRODUCTION

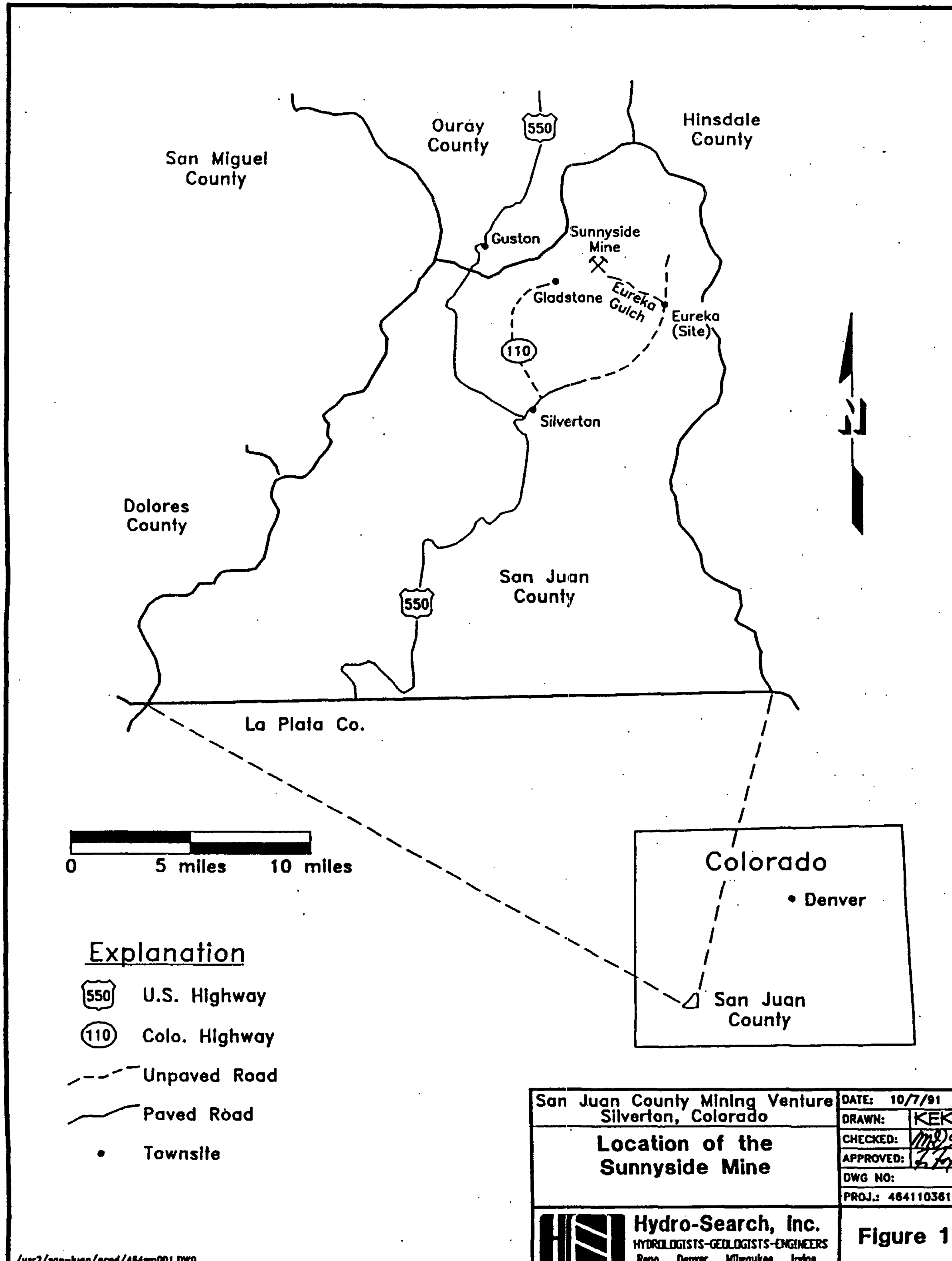
2.1 Location and Brief Description of the Sunnyside Mine

The Sunnyside Mine is located approximately 8 miles north of Silverton in the Eureka mining district in northernmost San Juan County, Colorado (Figure 1). Gold, silver, copper, lead, zinc, and cadmium ores have been produced from more than 150 miles of underground workings with a vertical extent of 2000 feet. The majority of the mine workings are located beneath Sunnyside Basin at the head of Eureka Gulch. Year-round access to the main part of the mine is via the 10,000 foot long American Tunnel, the portal of which is located at an elevation of 10,617 feet at the abandoned townsite of Gladstone. Secondary access is via the Terry Tunnel located in Eureka Gulch at an elevation of approximately 11,560 feet. The jeep trail to the Terry Tunnel is impassible during winter and spring.

2.2 Statement of Problem

As a result of water reacting with sulfide bearing rocks, drainage from both the American Tunnel and the Terry Tunnel is low pH and contains mobilized heavy metals. The San Juan County Mining Venture (SJCMV), owners of the Sunnyside Mine, would like to alter present flow patterns and/or water chemistry in order to reestablish approximate pre-mine hydrologic conditions.

In order to return to an approximation of pre-mine hydrology, it is first necessary to deduce the pre-mine hydrologic conditions. Present conditions must also be understood so that it will be



San Juan County Mining Venture
Silverton, Colorado

Location of the Sunnyside Mine

DATE: 10/7/91
DRAWN: KEK
CHECKED: [illegible]
APPROVED: [illegible]
DWG NO:
PROJ.: 464110361

Hydro-Search, Inc.
HYDROLOGISTS-GEOLOGISTS-ENGINEERS
Reno Denver Milwaukee Irvine

Figure 1

possible to devise a long term plan to deal with mine water discharge.

2.3 Scope of Report

The purpose of this report is to present a conceptual hydrologic model, including geochemistry, of the Sunnyside Mine area. The pre-mine ground- and surface-water hydrologic conditions are estimated, and the present hydrology, including flow within the mine workings, is summarized. This report is intended to be a source document which may be useful when formulating plans for dealing with drainage from the underground workings of the Sunnyside Mine.

2.4 Methods

Simon Hydro-Search bases this report on extensive review and analysis of published literature, mine records, files of public agencies, and field work at the Sunnyside Mine. Field work included a visual estimate of flow rates of drainages entering the mine, at various locations within the mine, at adjacent mine portals not owned by SJCMV, and at surface springs and seeps. Water temperature, pH, and electrical conductivity were measured at selected points.

Geologic features pertinent to hydrogeology were noted, such as the nature and orientation of faults, extent of mineralization and weathering, and geologic controls on springs and limonitic staining. Qualitative assessments were made of permeability of wall rock at selected locations within the underground workings.

3.0 HYDROLOGY PRIOR TO MINING

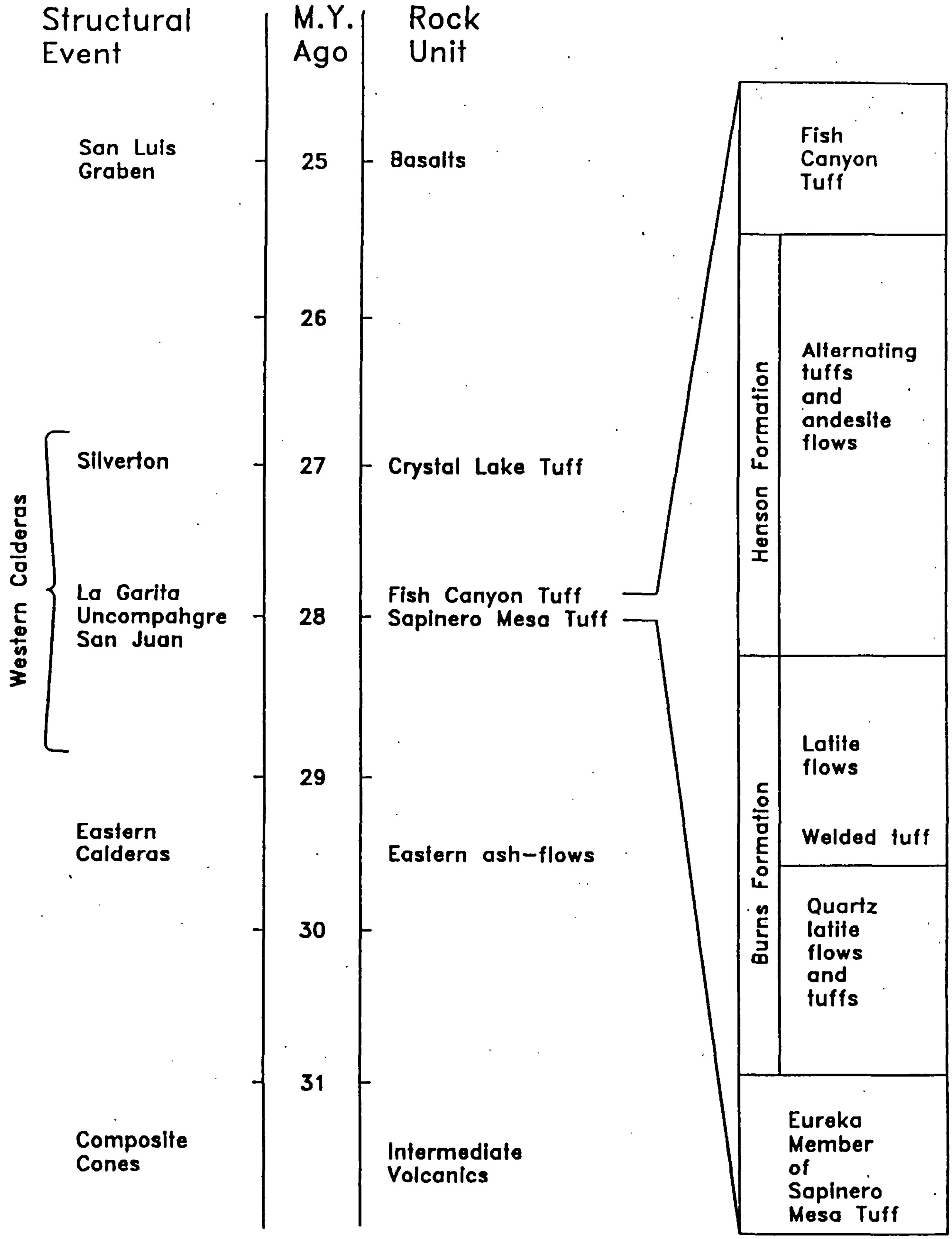
3.1 Pre-Mining Ground-Water Hydrology

3.1.1 Geology Pertinent to Ground-Water Flow and Chemistry

Rocks in the vicinity of the Sunnyside Mine are pyroclastics and flows which erupted from local calderas approximately 28 million years ago (Steven and Lipman, 1976). Local stratigraphy is summarized on Figure 2. The Sunnyside Mine is principally located within the Burns Formation, which generally consists of massive silica-rich latite flows which have locally been altered and mineralized. (Langston, pp. 34-39). The highest mine workings (above A level) extend into the overlying interbedded lava flows and air-fall tuffs of the Henson Formation, an alkali-rich andesite (Langston, p. 49).

The Burns Formation was erupted from vents within the San Juan caldera (Steven and Lipman, 1976, p. 11-12). The degree of welding of the upper Burns formation generally increases towards the west in the direction of the vent source (Langston, 1978, p. 11). The Henson Formation also was derived from vents located within the San Juan caldera, but typically is less welded than the Burns Formation and contains more pyroclastic units.

The extent of fracturing in volcanic rocks is directly related to the degree of welding if other factors are equal. Hence, the Burns Formation tends to be more fractured than the Henson Formation. The fact that many of the major veins in the Burns Formation pinch out approximately at the contact with the Henson (p. 68, Sunnyside Gold Corporation, 1985) may



San Juan County Mining Venture Silverton, Colorado	DATE: 10/10/91
Stratigraphic Column in the Vicinity of Sunnyside Mine, San Juan County, Co	DRAWN: KEK CHECKED: MDS APPROVED: [illegible] DWG NO: PROJ.: 464110361
Hydro-Search, Inc. HYDROLOGISTS-GEOLOGISTS-ENGINEERS Reno Denver Milwaukee Irvine	**Figure 2**

G:\SAN-JUAN\ACAD\464CH001.DWG

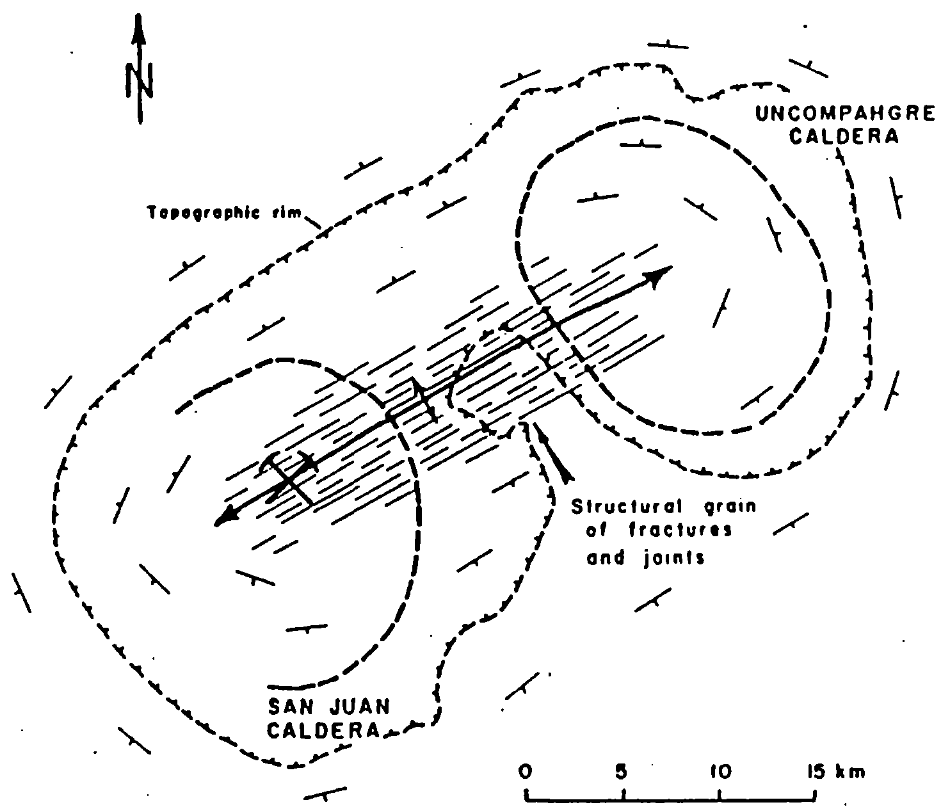
Modified from Langston, 1978

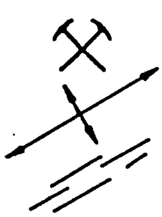
be explained by the lower degree of welding of the Henson Formation.

After the deposition of the Burns and Henson formations there was a broad resurgent doming between the San Juan caldera and the Uncompahgre caldera. This resurgent doming resulted in extensive distension fracturing in a northeast/southwest-trending direction (Steven and Lipman, 1976, p. 13) as shown in Figure 3. Later collapse of the resurgent doming along steeply dipping, northeast/southwest-trending fractures formed the Eureka graben. Arcuate faults related to the collapse of the Silverton caldera (such as the Bonita fault) appear to be contemporaneous with the bounding faults of the Eureka graben. Although some later faulting exists, the Eureka graben fracture system was the last major set of fractures imprinted on the area of the Sunnyside Mine. During mineralization 13.0 to 16.6 MYBP (Casadevall and Ohmoto, 1977), the fractures of this system served as flow conduits and sites for ore deposition.

The Sunnyside Mine is located within the Eureka graben at the junction of the Ross Basin fault and the Sunnyside fault as shown in Figure 4. Figure 4 also illustrates the dominant northeast/southwest fracture trend. In the vicinity of the mine, the dip of originally horizontal strata now ranges from 10° to 14° to the southwest (Langston, 1978, p. 17).

Rock alteration and mineralization is widespread in the vicinity of the San Juan caldera. "Propylitic alteration has affected many cubic miles of volcanic rocks throughout and beyond the [Silverton] caldera" (Burbank, 1960). In the propylitized rocks "pyrite is ubiquitous and forms between 0.1 and 2.0 percent" of the rock volume (Casadevall and Ohmoto, 1977, p.





Present location of Sunnyside Mine

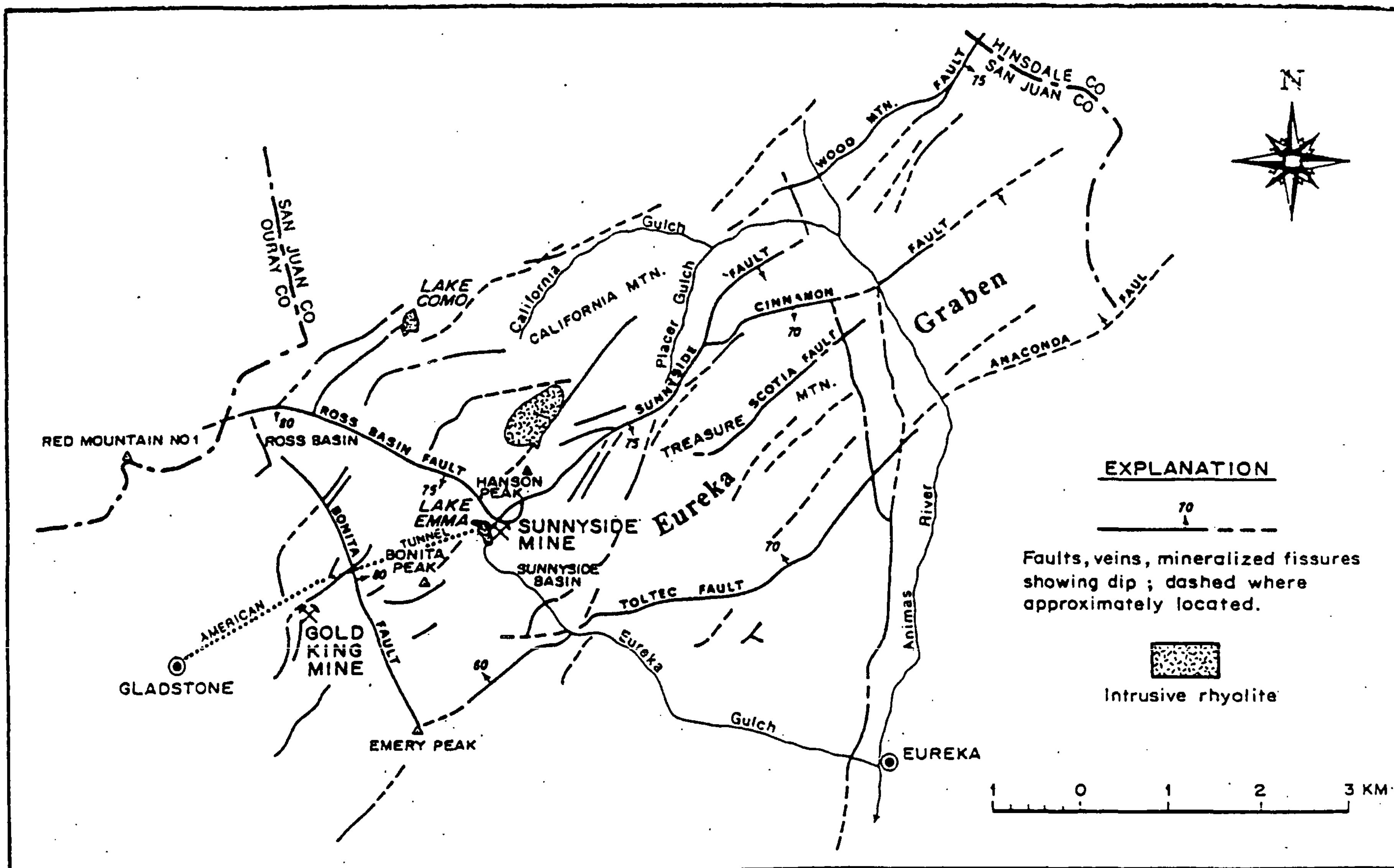
Approximate Axis of Resurgent Doming

Trend of Distension Fracture

Taken from Langston, 1978

San Juan County Mining Venture Silverton, Colorado	DATE: 10/10/91
Dominant Fracture System of the San Juan Caldera	DRAWN: KEK
	CHECKED: MDS
	APPROVED:
	DWG NO:
	PROJ.: 464110361
Hydro-Search, Inc. HYDROLOGISTS-GEOLOGISTS-ENGINEERS Reno Denver Milwaukee Irvine	Figure 3

G:\SAN-JUAN\ACAD\464SH002.DWG



San Juan County Mining Venture Silverton, Colorado	DATE: 10/10/91 DRAWN: KEK CHECKED: MDS APPROVED: [illegible]
Structural Geology in the Vicinity of the Sunnyside Mine, San Juan County, Co.	DWG NO: PROJ.: 464110361
Hydro-Search, Inc. HYDROLOGISTS-GEOLOGISTS-ENGINEERS	**Figure 4**

Figure from Casadevall and Ohmoto, 1977

1292). In excess of one billion tons of pyrite are estimated to exist in rocks in the vicinity of the Sunnyside Mine (assuming 5 cubic miles of propylitzed rocks with 1.0% pyrite). The weathering of this dispersed pyrite as well as other mineralization has resulted in the pervasive staining which is common in rocks throughout the area (e.g. Red Mountains 1, 2, and 3).

3.1.2 Bedrock Permeability

Permeability is the measure of the ability of a rock or soil to transmit a fluid (usually water) under a hydraulic gradient (Lohman, 1979). Much can be inferred about the permeability in the vicinity of the Sunnyside Mine based on site geology and hydrogeologic observations.

The intergranular permeability of pyroclastic sediments is typically very low and the intergranular permeability of volcanic flows and tuffs is insignificant. Freeze and Cherry (1979, p. 29) estimate the range of intergranular permeability of igneous rocks as varying from approximately 10^{-8} cm/sec to less than 10^{-11} cm/sec. In such rocks the vast majority of water is transmitted via secondary fracture permeability. The permeability of fractured igneous rocks ranges from 10^{-6} cm/sec to greater than 10^{-2} cm/sec. The location, extent, openness, and orientation of fracturing controls the hydraulics of the bedrock flow system.

Having properties that differ according to the direction of measurement (not identical in all directions)

Fracture permeability in the vicinity of the Sunnyside Mine is anisotropic. Permeability is greater in a northeast/southwest direction due to the dominant fracture orientation within the Eureka graben (see section 3.1.1). In addition, fracture permeability is greater in the welded tuffs and flows than in the unwelded units. The southwest dip in the vicinity of the mine results in zones of greater permeability which dip southwest along the more highly fractured units. The overall effect is that the greatest permeability zones trend northeast/southwest and dip about 10° - 14° southwest. Field evidence for this anisostropy in permeability includes a preferred orientation for ore shoots. Figure 5 shows an example of a northeast/southwest trending ore shoot which dips southwest.

The fracture permeability in the vicinity of the mine is inhomogeneous. In the upper Burns Formation fracture permeability is expected to increase from Sunnyside Basin toward Cement Creek as strata become more welded (now fractured) in the direction of the original volcanic vent (see section 3.1.1).

Fracture permeability generally decreases with depth as the fractures are progressively sealed by increasing overburden pressure. Evidence for this can be observed in both the American Tunnel and the Terry Tunnel. At locations deep within the mine water enters each tunnel only where major fractures are encountered, and most of the back and rib of the tunnel is dry. However, as the portals are approached decreasing overburden pressure allows relatively minor joints to transmit water and dripping water becomes common.

In the deeper parts of the flow system significant quantities of water are transmitted only by major fractures. This is demonstrated by the fact that the deeper part of the present American

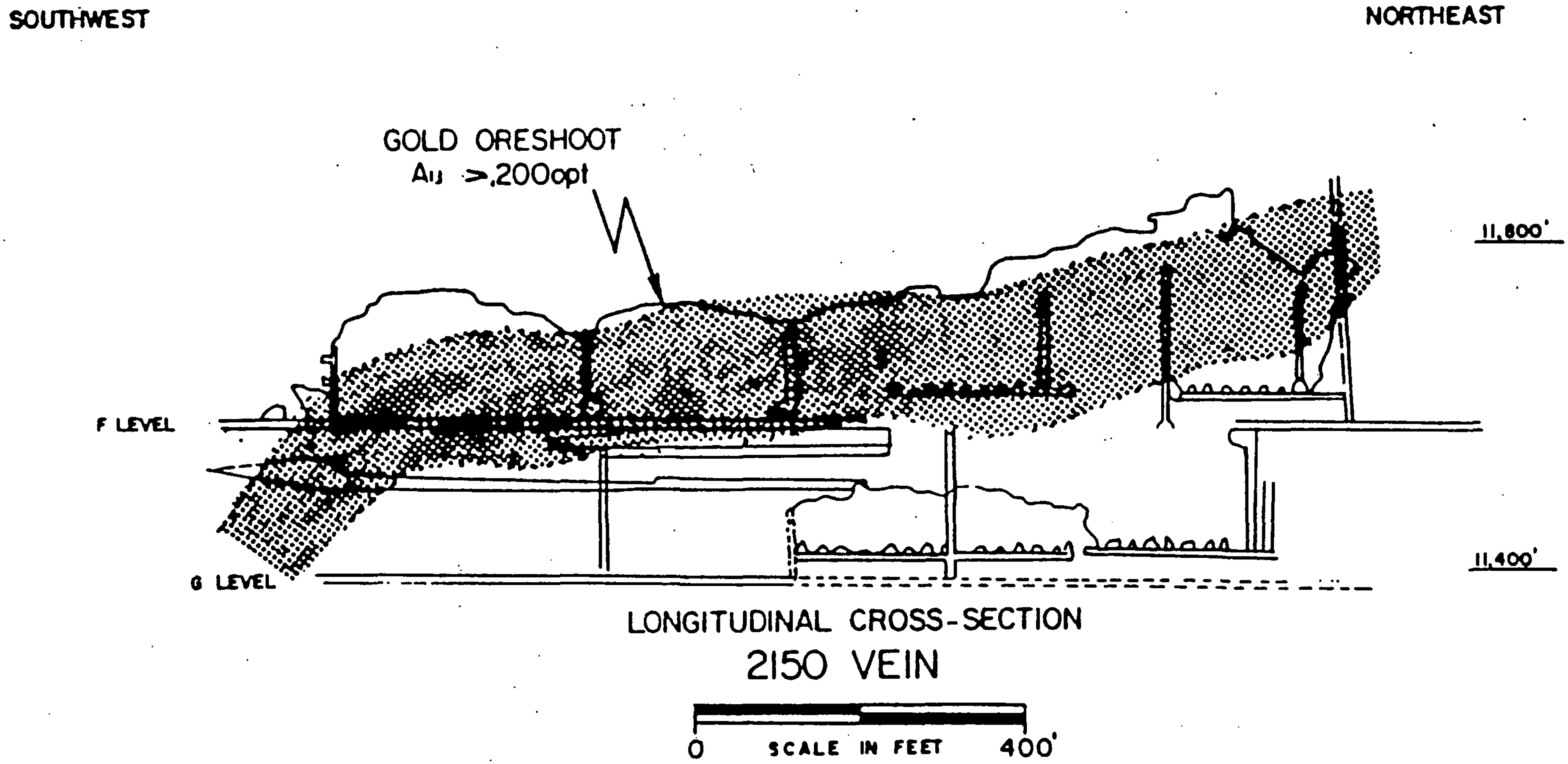


Figure from Sunnyside Gold Corporation, 1988

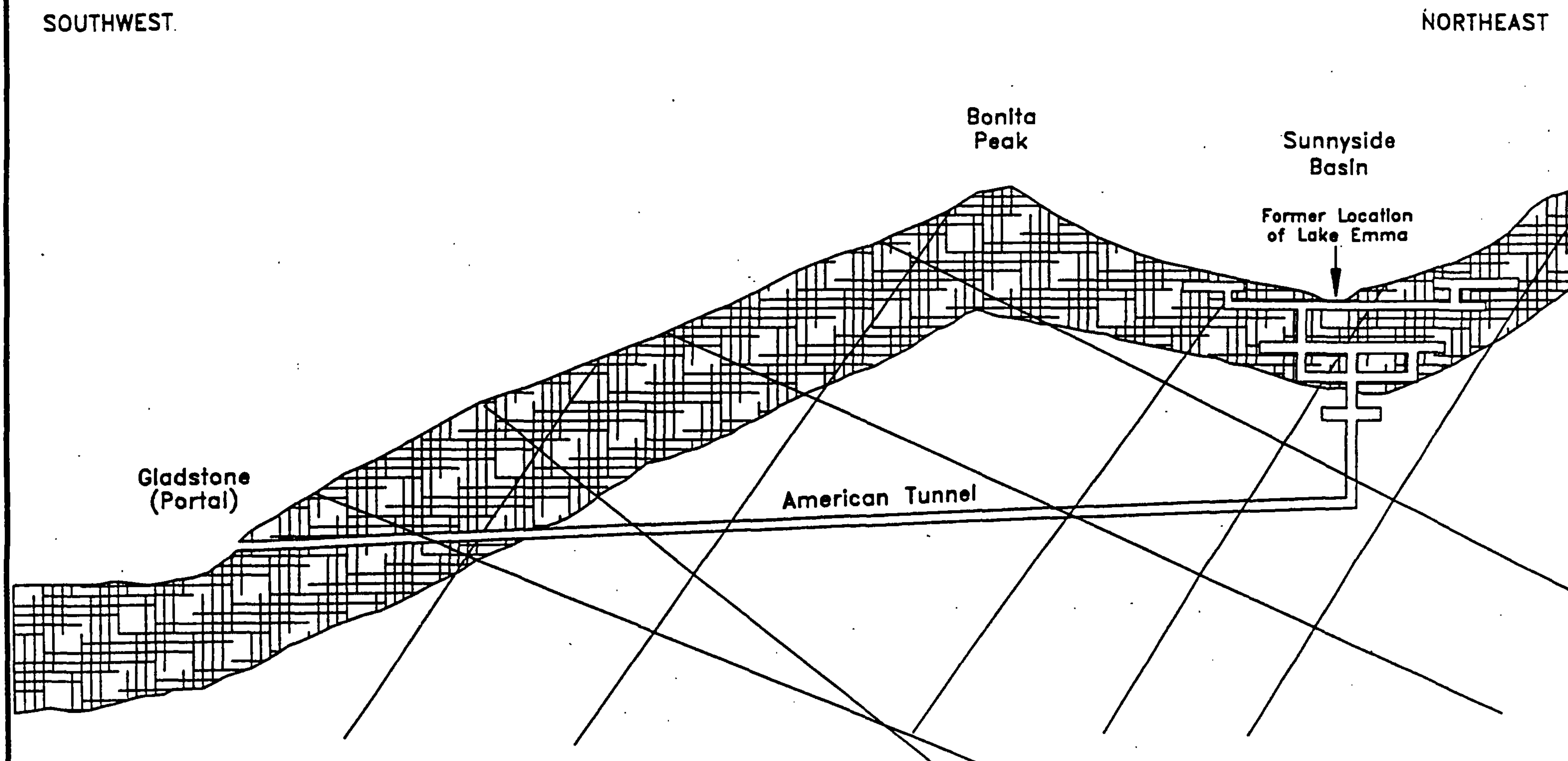
San Juan County Mining Venture Silverton, Colorado	DATE: 10/21/91
	DRAWN: KEK
A Southwest Raking Ore Shoot on the 2150 Vein Sunnyside Mine	CHECKED: MDS
	APPROVED: F. Fox
	DWG NO:
	PROJ.: 464110361
Hydro-Search, Inc. HYDROLOGISTS-GEOLOGISTS-ENGINEERS Reno Denver Milwaukee Irvine	Figure 5

/usr2/san-juan/acad/464gw002.DWG

Tunnel (beyond the Daylight Corner at approximately 2700 feet from the outside end of track[1]) has intercepted 1350 gpm of ground water. Of this 1350 gpm, 90 percent can be accounted for from the intersection of five major fracture zones (the Washington vein, the Sunnyside vein, the Brenneman vein, a fracture zone at the 0700 runaround, and a fracture zone located 3020 to 3220 feet from the end of track (see section 4.2.1). Figure 6 is a schematic diagram showing the manner in which fracture permeability changes with depth.

A dramatic demonstration of the localized nature of the fracture permeability in the deeper parts of the mine occurred when the American Tunnel first intercepted the Washington vein. During the late 1950's workings above the American Tunnel were flooded to approximately 50 feet below F Level according to Mr. Bob Ward, mine superintendent of the Sunnyside Mine at that time. This resulted in approximately 830 feet of hydraulic head over the American Tunnel. Diamond drilling was used to intercept the Washington vein from the face of the American Tunnel. When the vein was intersected the sustained water pressure and volume were so great that the full 150 feet of drill string was pushed back out of the hole into a twisted "spaghetti" of steel. A day later flow out of the 2-inch diameter hole was under enough pressure to shoot out approximately 20 feet from the drill hole. The estimated flow of water was approximately 580 gpm (see Appendix A). The nearest old workings on the Washington vein were located on I Level, approximately 350 feet higher than the American Tunnel. This indicates a very high permeability along the vein.

[1] All footages along the American Tunnel are referenced to track repair footages as marked on the tunnel wall. The track repair footages have a zero point just outside of the portal.



EXPLANATION

Zone where minor fractures transmit significant quantities of water.

Major fractures which transmit water even under considerable overburden pressure.

Mine workings.

NOT TO SCALE

San Juan County Mining Venture Silverton, Colorado	DATE: 10/23/91
	DRAWN: DRD
Schematic of Differing Fracture Permeability With Depth	CHECKED: MDS
	APPROVED:
	DWG NO:
	PROJ.: 464110381
Hydro-Search, Inc. HYDROLOGISTS-GEOLOGISTS-ENGINEERS	**Figure 6**

3.1.3 Bedrock Storage Coefficient

The storage coefficient is related to the interconnected porosity of a rock and is defined as the volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in the hydraulic head (Driscoll, 1986). The storage coefficient is dimensionless.

Crystalline volcanic rocks have very low primary porosity, but can develop moderate secondary porosity due to development of fractures (Freeze and Cherry, 1979). For unconfined conditions, storage coefficients are approximately equal to the effective porosity and range from 0.01 to 0.3. For confined conditions storage coefficients range from 0.001 to 0.00001 (Driscoll, 1986). The upper part of the zone of saturation is expected to be unconfined, and the deeper part of the flow system is expected to be confined by poorly welded zones of low permeability.

The storage coefficient can also be estimated using the relationship that storage coefficient varies directly with the thickness of the aquifer. The rule-of-thumb relationship from Todd (1980, p. 46) is as follows:

$$\text{Storage coefficient} = 3 \times 10^{-6} \times \text{aquifer thickness}$$

Based on the above relationships and past experience in volcanic terrains, the storage coefficient probably ranges from 0.01 to 0.005.

3.1.4 Pre-Mining Potentiometric Surface

Simon Hydro-Search has used observations from 1959 and 1961 to estimate the equilibrium static water level beneath the Sunnyside Basin. Mr. Bob Ward (mine superintendent during construction of the American Tunnel) personally saw that the static water level in the Washington Inclined Shaft was approximately 50 feet below F level during the summer of 1959. Mr. Ward's recollection appears reasonable in light of a letter from D. Hutchinson to Messrs. William R. McCormick and Robert M. Hurst dated February 3, 1961. This letter states that during January of 1961 (after the American Tunnel had intersected some of the fractures under the old workings) "the water was 97 feet below F level and falling 3½ feet per day". The observed water levels in 1959 and 1961 were below F level where drainage to the surface would have occurred via the Terry Tunnel. The 1959 static water level reflects a lack of dewatering during the preceding 20-year period during which time the mine was inactive. The 1959 static water level is thought to represent an equilibrium condition of inflow to the workings versus outflow via natural fracture permeability. It is worth noting that this static water level is deep enough that most of the minor joints would be sealed by the overburden pressure (see Section 3.1.2).

Direct surface-water inflow to the mine in 1959 was far less than today. Hence, the static water level in 1959, estimated at 11,500 feet above mean sea level (msl), is assumed to approximate the static water level in the fractured bedrock prior to commencing mining.

Lake Emma was a glacial tarn in Sunnyside Basin at an elevation of approximately 12,250 feet msl. On June 4, 1978 Lake Emma drained into workings on the Spur vein causing extensive damage throughout the mine (Bird, 1986, p. 135). In areas of high permeability a lake can usually be considered to represent the water table. However, this does not appear to have been the case for Lake Emma. Two samples of the lacustrine clays which formerly were under Lake Emma were tested in August 1988 and shown to have permeabilities ranging from 1.6 x 10^{-7} to 6.7 x 10^{-9} cm/sec under 95% relative compaction (see Appendix B). These permeability values are very low and little water would have been transmitted through such material. Lake Emma is considered to have been perched on low permeability lacustrine clays and/or poorly fractured Henson Formation.

source is single observation

Prior to the existence of the mine the gradient was approximately 0.1 feet/foot from the head of Sunnyside Basin to either Cement Creek, at Gladstone, or to the Animas River at the site of Eureka (see Table 1). If the pre-mine hydraulic head under Sunnyside Basin had been higher or lower the hydraulic gradient would have a different value, but the rate of change in gradient would be about the same to the southeast (toward Midway Mill site) as to the southwest (toward Gladstone).

If permeability had been homogeneous and isotropic the ground water might have moved in either direction. However, as discussed in section 3.1.2 a strong anisotropy exists with enhanced permeability both in a northeast/southwest direction and also dipping southwest. In

Table 1: Estimated Pre-Mine Ground-Water Gradient within the Fractured Bedrock			
	Elevation[1] (feet msl)	Distance[1] from Workings under Sunnyside Basin (feet)	Gradient[2] from head of Sunnyside Basin to indicated point
Cement Creek near Portal of American Tunnel	10,500	9,500	0.105
Discharge Zone near Mogul Mine Portal	11,250	6,300	0.040
Animas River at Site of Eureka	9,850	15,600	0.106
Eureka Gulch near Midway Mill Site	10,480	9,300	0.110

1) Estimated from U.S.G.S. Handies Peak and Ironton 7 1/2 minute quadrangles

2) Assumes the pre-mine hydraulic head in the fractured bedrock beneath Lake Emma was approximately 11,500 feet above mean sea level (based on the 1959 water-level observation of Mr. Bob Ward).

addition, greater fracture permeability associated with a higher degree of welding of the volcanics is expected beneath the Gladstone area than beneath the Sunnyside Basin. The local anisotropy and inhomogeneity of the fracture permeability would facilitate ground-water movement toward Cement Creek. Hence, the majority of water in the bedrock flow system is inferred to have moved from the Sunnyside Basin to the Cement Creek drainage where it discharged as springs and seeps.

Field evidence supports the idea that the preferred ground-water flow direction is southwest rather than southeast in the vicinity of the Sunnyside Mine. Field observations by Simon Hydro-Search staff during July and August, 1991 located a greater number of visible springs and seeps in the Cement Creek drainage, above Gladstone, than in Eureka Gulch. Furthermore, the springs and seeps in the two forks of Cement Creek above Gladstone are preferentially located on the east side of the creek, indicating a source to the east is most likely. Finally, based on the volume of dumps, the Silver Ledge Mine, located on the east side of the South Fork of Cement Creek, appears to have approximately the same extent of underground workings as the Big Colorado Mine located on the adjacent opposite side of creek. Yet, based on the present flow from the portals, the Silver Ledge Mine intercepted approximately ten times as much water as the Big Colorado Mine.

3.1.5 Pre-Mining Ground-Water Chemistry

Prior to any mining, ground water in the vicinity of the Sunnyside Mine is thought to have had a higher level of dissolved metals and a lower pH than ground water in unmineralized areas.

The anomalous metals content and low pH was caused by the oxidation of sulfides along fractures - both mineralized fractures and fractures with only the background disseminated sulfides. These oxidation reactions are responsible for the extensive limonitic staining so common in the San Juan Mountains (e.g. Red Mountains 1 and 3 adjacent to Gladstone).

The chemistry of ground water can be measured from samples from wells and springs. No deep wells exist in the vicinity of the Sunnyside Mine, but chemical parameters have been measured at springs in the Cement Creek drainage, and discharge from fractures within the Sunnyside Mine.

is the reverse true.

Table 2 summarizes selected chemical parameters of waters entering the American Tunnel. Most of the water in the vicinity of Washington Inclined Shaft (Washington vein, West Drift, and Sunnyside Drift) originates as ground water which has entered the fracture-flow system in or near the Sunnyside Basin and has had a relatively short flow path to the mine workings. Ground water from Fault #1 and Fault #2 seems to have traversed a greater distance from the recharge area.

Water from the Hanging Wall Drift of the Washington vein is slightly warmer than other mine flows and is expected to contain some ground water rising from depth. This rising of ground water may be induced by the decrease in hydraulic head associated with dewatering the mine. This water should not contain elevated levels of metals or acid caused by exposure of sulfides

Table 2: Selected Chemical Parameters of Waters Entering the American Tunnel Level of the Sunnyside Mine											
Sample Location	Date	Lab	Zn mg/l	Pb mg/l	Mn mg/l	Cu mg/l	Cd mg/l	Fe mg/l	As mg/l	lab pH	Conductivity
Washington Vein Hanging Wall	3/5/91	R&N	0.59	0.19	1.58	0.03	0.005	0.17	—	7.18	—
	3/5/91	IML	0.75	<0.005	2.01	<0.01	0.005	0.07	<0.005	7.54	1860
	3/13/91	IML	0.98	<0.005	2.21	<0.01	<0.002	0.06	<0.005	7.17	1990
	3/13/91	R&N	0.95	0.15	2.18	0.02	0.002	0.22	—	7.53	—
	Average		0.82	0.09	2.00	0.02	0.003	0.13	0.005	1736	1925
Washington Vein Foot Wall	3/5/91	R&N	33.43	0.21	64.29	0.13	0.090	0.38	—	7.68	—
affected by	3/5/91	IML	34.3	<0.005	61.9	<0.01	0.073	<0.05	<0.005	7.24	1850
	Average		33.9	0.11	63.1	0.07	0.082	0.22	0.005	7.46	1850
West Drift	3/5/91	R&N	16.70	0.24	18.65	0.205	0.106	15.5	—	6.73	—
mining	3/5/91	IML	17.9	<0.005	17.7	<0.01	0.082	5.47	<0.005	6.71	1740
	Average		17.3	0.12	18.2	0.11	0.094	10.5	0.005	6.72	1740
Sunnyside Drift	3/5/91	R&N	0.09	0.18	1.83	0.02	<0.002	0.25	—	7.57	—
	3/5/91	IML	0.09	<0.005	2.10	<0.01	0.003	0.14	<0.005	7.60	1340
	3/13/91	IML	0.06	<0.005	1.87	<0.01	<0.002	<0.05	<0.005	7.18	1430
	3/13/91	R&N	0.07	0.08	1.94	0.01	0.004	0.18	—	7.60	—
	Average		0.08	0.07	1.94	0.01	0.003	0.15	0.005	7.49	1385
Fault #1	3/5/91	R&N	47.08	0.21	91.4	0.34	0.064	334.0	—	5.9	—
Fault #2	3/5/91	R&N	70.1	0.59	132.6	0.03	0.106	531.0	—	6.05	—
Fault #2	3/5/91	IML	92.1	0.425	151	<0.01	0.089	537.	<0.005	—	—

Notes:

[1]R&N is Root & Norton Laboratories of Silverton, Colorado. Analyses are for total recoverable metals.

[2]IML is Inter-Mountain Laboratories, Inc. of Farmington, New Mexico. Analyses are for dissolved metals.

by mining activities, yet it contains relatively high concentrations of lead and manganese. The Sunnyside Cross Cut did not intersect any significant mineralization. Water from the Sunnyside Cross Cut therefore should not be significantly impacted by oxidation of sulfides exposed by mining; yet it also contains relatively high concentrations of lead and manganese. Waters from the West Drift and Footwall Drift may contain a relatively small volume of water which cascades down from open stopes after reacting with exposed sulfides and oxygen. Waters from the West Drift and Footwall Drift should not be considered to represent ground-water chemistry.

Fault #1 and Fault #2 intersect the American Tunnel a little over one half mile from the portal (between track repair footages 3000 and 3250). Ground water entering the tunnel at these locations contains much greater concentrations of dissolved metals and has a lower pH than ground water in the vicinity of the Washington Inclined Shaft. Water from Fault #1 and Fault #2 contains high concentrations of zinc, lead, manganese, cadmium and iron. The increased concentrations of metals and lower pH may be due to a longer flow path or greater residence time within the deep fracture-flow system.

Seeps associated with considerable iron staining of soil are locally known as iron bogs. Such iron bogs are common along both the north and south forks of Cement Creek. The iron staining is due to iron oxides and hydroxides precipitating out of metal laden ground water. There are iron bogs associated with most of the abandoned mine portals, but iron bogs also exist where there are no mines located uphill (such as near the head of the South Fork of Cement Creek). The iron bogs located near abandoned portals may be accentuated by water which has picked up metals and acid while percolating through sulfide-bearing dumps. However, the presence of iron bogs away from old workings proves that natural seeps also carried anomalous loads of metals (and probably acid). The iron bogs located near old mine workings probably pre-date the workings. Prospectors consider iron staining to be a good indication of mineralization and often drove test tunnels into limonite-stained rock.

Iron bogs are formed as a result of iron-laden ground water discharging as springs and seeps. The relatively low redox potential of ground water allows iron to remain in solution in the subsurface. When iron-laden ground water is discharged to the surface, the iron is oxidized and precipitates as hydroxides and/or oxyhydroxides. Many other heavy metals tend to be adsorbed onto the iron precipitate and are removed from solution. The precipitation process is accompanied by the release of hydrogen ions (Garrells and Christ, 1965, p. 189) which lowers pH. The net effect is that a significant part of the dissolved metals load of ground water is removed from solution soon after the water surfaces, but the water becomes more acidic.

A pH of 4.5 was measured at a sizable natural discharge zone near the Mogul Mine portal on July 31, 1991 by Simon Hydro-Search staff. A pH of 4.24 was measured at the same discharge zone on October 17, 1991 by SJCMV staff. The pH measurements were made at a location which was upstream of the waters flowing from the Mogul Mine portal. This discharge zone appears to be localized by the Bonita fault (see Figure 4). The Bonita fault is perpendicular to the dominant northeast/southwest fracture trend and is expected to intercept ground water from such fractures. A low pH may be typical of water which has traversed the full extent of the

3.1.6 Recharge to the Ground-Water System

The primary recharge mechanism for the bedrock aquifers in the mountains north of Silverton is infiltration of rain and snowmelt. The average annual precipitation in the upper reaches of Cement Creek and Eureka Creek between 1921 and 1950 was approximately 45 inches, of which approximately 30 inches occurred as snow (Iorns, et al., 1964). A simple water balance can be performed to estimate the amount of annual recharge to the bedrock aquifer by subtracting runoff, sublimation, and evapotranspiration values from the precipitation. The United States Geological Survey has estimated the annual runoff from the high mountain basins north of Silverton at between 10 inches (Longbein, et al., 1949) and 20 inches (Gebert, 1987). The total losses from an alpine snowpack above timberline (via evaporation, sublimination, and wind transport) are approximately 50 to 60% (Meiman and Grant, 1974). Therefore, the total remaining precipitation contributed by snowfall on an average annual basis (1921-1950) is between 12 and 15 inches. Considering the short growing season at high altitude, the average evapotranspiration rate for alpine meadow is expected to be low.

Taking the average of the range of values for precipitation, losses to snowpack, and runoff, the amount of annual precipitation available for recharge to the ground-water system is estimated at 8.5 inches. Using minimum values results in an estimate of only 2 inches of recharge per year.

3.1.7 Discharge from the Ground-Water System

Prior to mining, ground water discharged from the bedrock flow system via springs and seeps in the major drainages. The overall ground-water discharge rate in the Cement Creek watershed and Eureka Gulch was probably very close to the overall recharge rate.

The base flow of the master stream in a watershed equals the total ground-water discharge to the watershed, minus evapotranspiration along creeks and near springs. The base flow of the North Fork of Cement Creek just above Gladstone is presently 230,000 gallons per day (gpd). According to SJCMV records, the base flow of Eureka Creek below the Terry Tunnel is presently somewhat greater than 170,000 gpd (170,000 gpd plus the flow from McCarty Basin).

Dewatering of the Sunnyside Mine may have reduced the flow of some springs and seeps along Cement Creek by reducing the hydraulic gradient toward the springs. Thus, the pre-mine ground-water discharge along Cement Creek was probably significantly greater than today. The recharge estimate of 8.5 inches (Section 3.1.6) indicates that the total pre-mine ground-water discharge should have been approximately 4 ½ times greater. However, the minimum recharge estimate would match present observed flows.

3.2 Pre-Mining Surface-Water Hydrology

3.2.1 Surface-Water Flow

Surface water in the area occurs in small mountain lakes and as stream flow in the drainages. Stream flow varies considerably. High flow rates occur during the spring in response to melting snow and thunderstorms. The flow in the North Fork of Cement Creek just above Gladstone presently ranges between 15.7 million gallons per day (mgd) at the end of May to 0.23 mgd at the end of January. The flow in Cement Creek above Gladstone may have been greater prior to mining due to increased discharge from springs (see section 3.1.7). The flow in Eureka Creek just below the Terry Tunnel typically ranges from 7.2 mgd in early June to 0.17 mgd in late October. The flow in Eureka Creek was calculated by adding the measured flow above the Terry Tunnel to the measured flow from the Terry Tunnel and does not include the flow from McCarty Basin (which is not measured). The rate of flow in Eureka Creek (below the present portal of the Terry Tunnel) probably has not been significantly affected by mining.

3.2.2 Surface-Water Chemistry

There are no recorded measurements of the water chemistry of Eureka Creek or Cement Creek prior to mining. Early accounts, at the very onset of mining in the 1870's, relate that locally the natural quality of water was so poor that certain streams were "undrinkable" (Rhoda, 1984). This is not surprising considering the tremendous volume of sulfides dispersed throughout the bedrock (see section 3.1.1). These sulfides react with meteoric water to release acid and mobilize metals.

Eureka Creek above the Terry Tunnel is presently neutral (average pH from 1987-1991 was 7.1). Eureka Creek above the Terry Tunnel may have had a lower pH prior to mining because surface drainages flowing over outcrops within the highly mineralized Sunnyside Basin would be expected to have reacted with sulfides. For example, a drainage above the Washington Vein has shown a mean field pH value of 6.0 over the period 1987-1991. This drainage passes over mineralized bedrock, but does not pass through any mine workings prior to sampling. Water from this drainage shows elevated concentrations of heavy metals including the following average values over the period 1987-1991: 0.0037 mg/l of cadmium, 0.033 mg/l of copper, 0.17 mg/l of lead, and 1.9 mg/l of zinc (Appendix C). The preceding averages assume the detection limit value was present when an element could not be detected. The range of values is large and depends on the quantity of flow, etc. The maximum measured concentrations for the same elements are as follows: 0.012 mg/l of cadmium, 0.17 mg/l of copper, 0.882 mg/l of lead, and 5.9 mg/l of zinc. These surface drainages are now largely routed through the mine workings and out the Terry Tunnel.

Many iron bogs are present in both the North and South Forks of Cement Creek, indicating metal-laden water is, or has been, discharging to Cement Creek. As discussed in section 3.1.5, prior to mining the springs discharging to the Cement Creek drainage above Gladstone probably had a pH of less than 5 and had elevated levels of metals. Therefore, the pH of the base flow of Cement Creek would also have been less than 5.0. The pH and metals content of Cement Creek would have varied depending on snowmelt and precipitation conditions.

As in Sunnyside Basin, many surface drainages which are tributary to Cement Creek pass over mineralized bedrock and react with sulfides. A pH of 4.4 was measured on August 2, 1991 in one such tributary to the South Fork of Cement Creek. No mine development, historical or active, exists upstream of where this measurement was taken.

4.0 PRESENT HYDROLOGY

4.1 Present Ground-Water Hydrology

4.1.1 Bedrock Permeability

The permeability characteristics of the bulk of the ground-water flow system have not been affected by the excavation of the underground workings of the Sunnyside Mine. These characteristics are detailed in section 3.1.2.

Within the voids created by mining the permeability is extremely high, and resistance to flow is mainly a function of the kinematic viscosity of the water. The majority of the underground mine workings are located beneath the Sunnyside Basin within an area extending 4000 feet from east to west, and 2500 feet from north to south. However, the workings now form a direct connection from the ground-water flow system beneath Sunnyside Basin to the Cement Creek watershed via the American Tunnel.

The excavation of the underground workings has involved a tremendous amount of blasting. The fractures induced by blasting for underground mining activities propagate less than 20 feet from the blast site (Siskind and Fumanti, 1974; Worsey, 1985; and Worsey, 1986). Hence, the zone of enhanced permeability due to mining is limited to the immediate vicinity of workings and to a few near-surface areas where workings have self-stoped upwards.

4.1.2 Bedrock Storage Coefficient

The characteristics of the storage coefficient in the bulk of the ground-water flow system have not been affected by excavation of the Sunnyside Mine. These characteristics are described in section 3.1.3.

The storage coefficient will be equal to 1.0 within the voids created by mining. However, the actual volume of voids created by mining is relatively small when compared to the total volume of rock beneath the Eureka and Cement Creek watersheds.

4.1.3 Potentiometric Surface

The present potentiometric surface in the vicinity of the Sunnyside Mine probably resembles the pre-mining potentiometric surface (see section 3.1.4) except in the immediate vicinity of underground workings or major permeable fractures which intersect these workings. The hydraulic head has been decreased in the underground workings by approximately 830 feet based on an equilibrium static water level of approximately 50 feet below F level (see section 3.1.4).

Major permeable fractures have a hydraulic gradient toward the mine workings as indicated by inflow to the American Tunnel level from the Brenneman, Washington, and Sunnyside veins, among others. Within these fractures the high permeability results in a relatively gentle gradient toward the mine workings. Ground water from these fractures would have eventually traveled to natural discharge points along the Cement Creek drainage. Flow from these fractures is, in effect, taking a faster flow path to the Cement Creek watershed than it would have had under natural conditions.

Adjacent to underground workings in those areas where major fractures do not exist, the hydraulic gradient is very steep in the direction of the mine workings. For example, diamond drill holes oriented perpendicular to the American Tunnel at the 0700 and 1500 "runarounds" encountered water under considerable pressure when they intersected permeable fractures. Some of these diamond drill holes have been partially cased and equipped with valves. Even today, one of these valved holes will spurt over 30 gpm across the full width of the runaround when opened. It is very likely that there are saturated fractures directly above most of the American Tunnel.

4.1.4 Ground-Water Chemistry

The water chemistry of the bedrock flow system has probably not been significantly altered by the presence of the Sunnyside Mine. The water chemistry of the bedrock flow system is described in section 3.1.5. The water chemistry of the open channel flow within the Sunnyside Mine workings is described in section 4.2.2.

4.1.5 Recharge to the Ground-Water System

Recharge to the ground-water flow system (which is not considered to include open channel flow within underground workings) has probably not been significantly affected by the presence of the Sunnyside Mine. There may be a slight decrease in recharge due to the draining of Lake

Emma, which formerly would have been leaking to the ground-water system through low permeability lacustrine clays.

4.1.6 Discharge from the Ground-Water System

The discharge from the ground-water flow system may be temporarily enhanced by the presence of the Sunnyside Mine. As discussed in section 3.1.7 the base flow of Eureka Creek below the Terry Tunnel is now somewhat greater than 170,000 gpd. The base flow of the North Fork of Cement Creek above Gladstone is approximately 230,000 gpd. However, at Gladstone the American Tunnel discharges a flow of approximately 3,100,000 gpd (based on an October 1991 measurement). Most of the flow from the American Tunnel originates as ground water from permeable fractures. The Sunnyside Mine has removed ground water from storage and induced an irregular cone of depression in the potentiometric surface. When recharge to the fractures equals discharge from the fractures an equilibrium will exist in which no more water will be removed from storage. American Tunnel flows mentioned in letters from D. Hutchinson to Messrs. McCormick and Hurst in 1961 are greater (up to 2,500 gpm) than the flow measured by SJCMV in October, 1991 (2,160 gpm), but it is likely that the system is now nearly at equilibrium. If the drainage of these fractures has not yet reached equilibrium, then discharge from the ground-water flow system has been temporarily enhanced.

As discussed in section 3.1.7 the discharge of springs and seeps in the Cement Creek watershed may have decreased due to dewatering of the Sunnyside Mine. However, the base flow of

Cement Creek below Gladstone is now equal to or greater than the pre-mine base flow due to the discharge from the American Tunnel.

4.2 Mine Hydrology

4.2.1 Open Channel Flow Within the Underground Workings

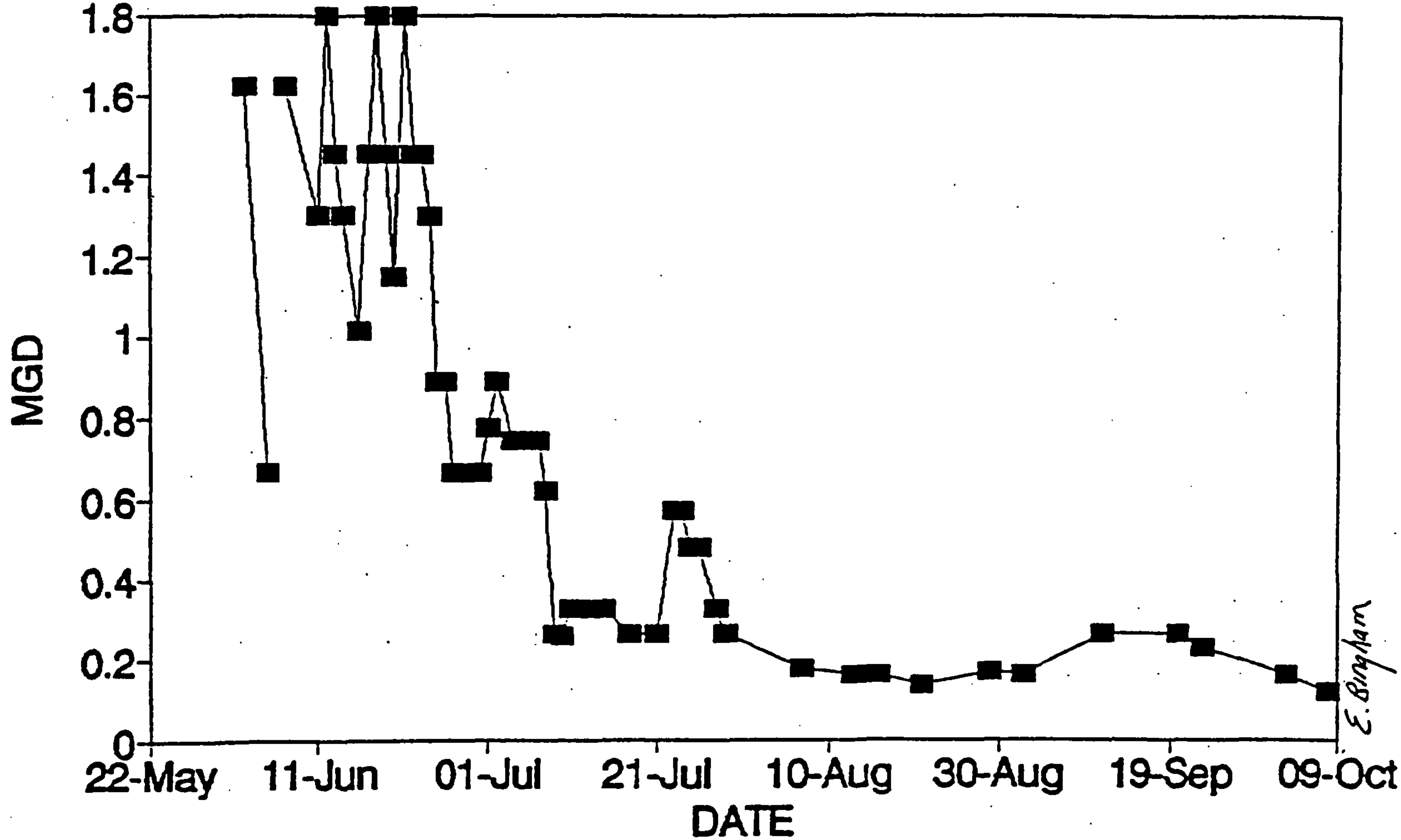
A considerable volume of water moves through the underground workings of the Sunnyside Mine. In the upper workings of the mine (F level and above) the majority of this water results from the capture of surface drainages and shallow perched ground water in the Sunnyside Basin. At the level of the American Tunnel (the lowest level of the mine) most of the water drains from the ground-water flow system.

A large percentage of the surface water from the head of Eureka Gulch drains into the underground workings of the Sunnyside Mine via the Lake Emma Hole and other places where workings intersect the land surface. The F level is a major haulage level and most stopes have a floor on that level. Hence, the majority of surface water entering the mine moves down to F level and then flows along F level and out of the Terry Tunnel. Mr. Larry Perino (present Superintendent of Technical Services at the Sunnyside Mine) made a visual estimate that flow from the Terry Tunnel ranged from 5 gpm in autumn to 100 gpm during spring runoff in 1978. After 1978, additional working of near-surface veins resulted in opening the Lake Emma Hole and self-stoping of other workings to the surface. As a result of the increased surface drainage, the measured flow from the Terry Tunnel now varies from 82 gpm in autumn to at least 1400 gpm during spring runoff.

Figures 7 and 8 illustrate the present seasonal variation in flow from the Terry Tunnel. Flow from the Terry Tunnel is measured with an "H" flume below the settling ponds. Flow measurements from 1988 through fall of 1990 may be somewhat underestimated due to pond leakage (which is now insignificant) and inadequate leveling of the flume. No measurements are taken during winter and spring because the access road to the Terry Tunnel is typically impassible until late May. Figure 7 shows a peak flow in early June, but it is possible that the peak flow may have occurred prior to the first gauging in some prior years.

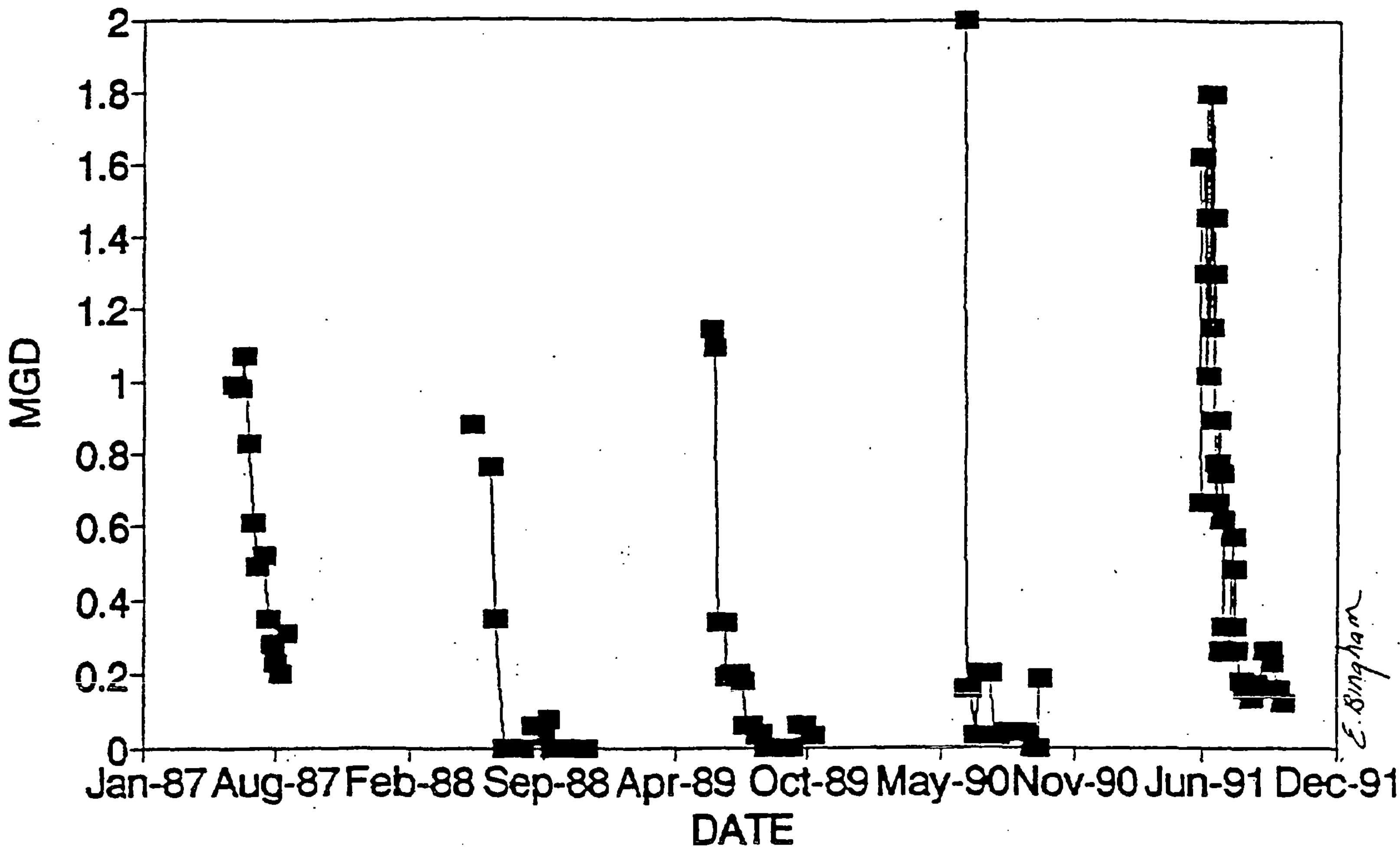
Flow from the American Tunnel is much more constant than flow from the Terry Tunnel. Figure 9 is a hydrograph of flow rates from the American Tunnel as measured using a Parshall flume downstream of the settling ponds at Gladstone. Flows less than 1.8 million gallons per day (mgd) or greater than 2.6 mgd are probably caused by pond cleaning activities. Flow rate from the American Tunnel is relatively constant throughout the year because the overwhelming majority of the flow originates as ground-water discharge (from fractures), rather than as surface drainage into the mine workings.

Flow measurements with a pygmy meter at the lime treatment plant just downstream of the portal of the American Tunnel (Table 3) shows a flow rate approximately 35% greater than the flow rate below the settling ponds (Figure 9). The reason for the difference is presently under investigation by SJCMV.



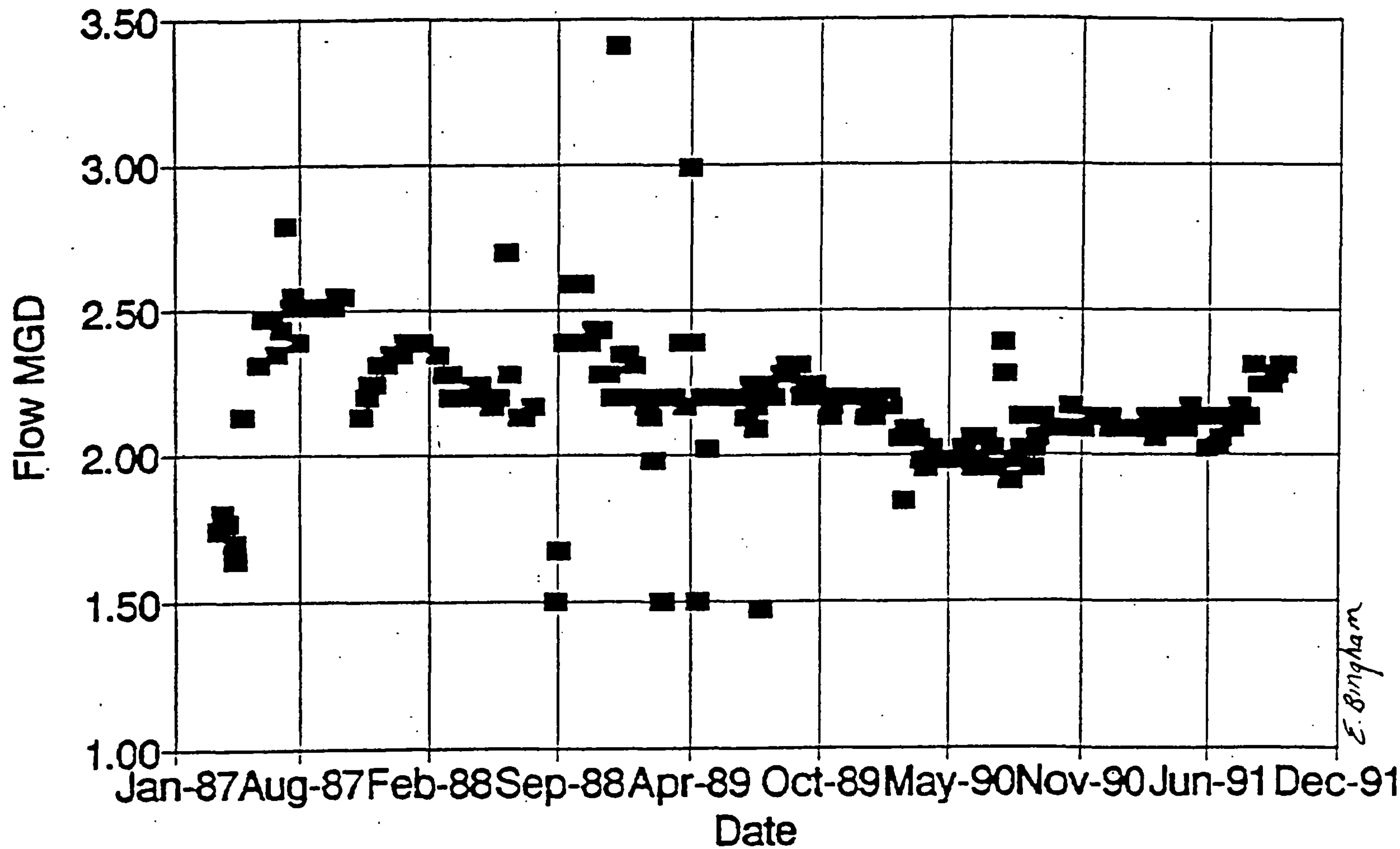
San Juan County Mining Venture Silverton, Colorado	DATE: 10/22/91
Hydrograph of Flow from the Terry Tunnel: Detail of 1991	DRAWN: DRJ
	CHECKED: MDS
	APPROVED: F. Fox
	DWG NO:
	PROJ.: 464110361
Hydro-Search, Inc. HYDROLOGISTS-GEOLOGISTS-ENGINEERS Reno Denver Milwaukee Irvine	Figure 8

/usr2/san-juan/acad/464ch006.DWG



San Juan County Mining Venture Silverton, Colorado	DATE: 10/22/91
	DRAWN:
Hydrograph of Flow from the Terry Tunnel: 1987-1991	CHECKED:
	APPROVED:
	DWG NO:
	PROJ.: 464110381
Hydro-Search, Inc. HYDROLOGISTS-GEOLOGISTS-ENGINEERS Reno Denver Milwaukee Irvine	Figure 7

/usr2/san_juan/acad/464ch005.DWG



NOTE

1. Flows measured at outlet of settling pond.

San Juan County Mining Venture Silverton, Colorado	DATE: 02/11/92
	DRAWN: URD
Hydrograph of Flow from the American Tunnel: 1987-1991	CHECKED: MDS
	APPROVED: F.H.
	DWG NO:
	PROJ.: 464110361
Hydro-Search, Inc. HYDROLOGISTS-GEOLOGISTS-ENGINEERS Reno Denver Milwaukee Irvine	Figure 9

/usr2/san-juan/acad/464ch007.DWG

Table 3. Measured Flows in the American Tunnel	
Footage from Portal [1]	Flow Rate [2] (gallons per minute)
8150	620
7350	590
6400[3]	930
3420	890
2700	1350
2400	1470
0[4]	2160

1 Footages are "track repair footages" as marked on the wall of the American Tunnel and are approximate.

2 Flow was measured with a pygmy flow meter by Evelyn Bingham and Guy Lewis of SJCMV on October 2 - 3, 1991.

3 This measurement point is near the property line between SJCMV and Gold King.

4 Measurement was actually just upstream of the lime treatment plant.

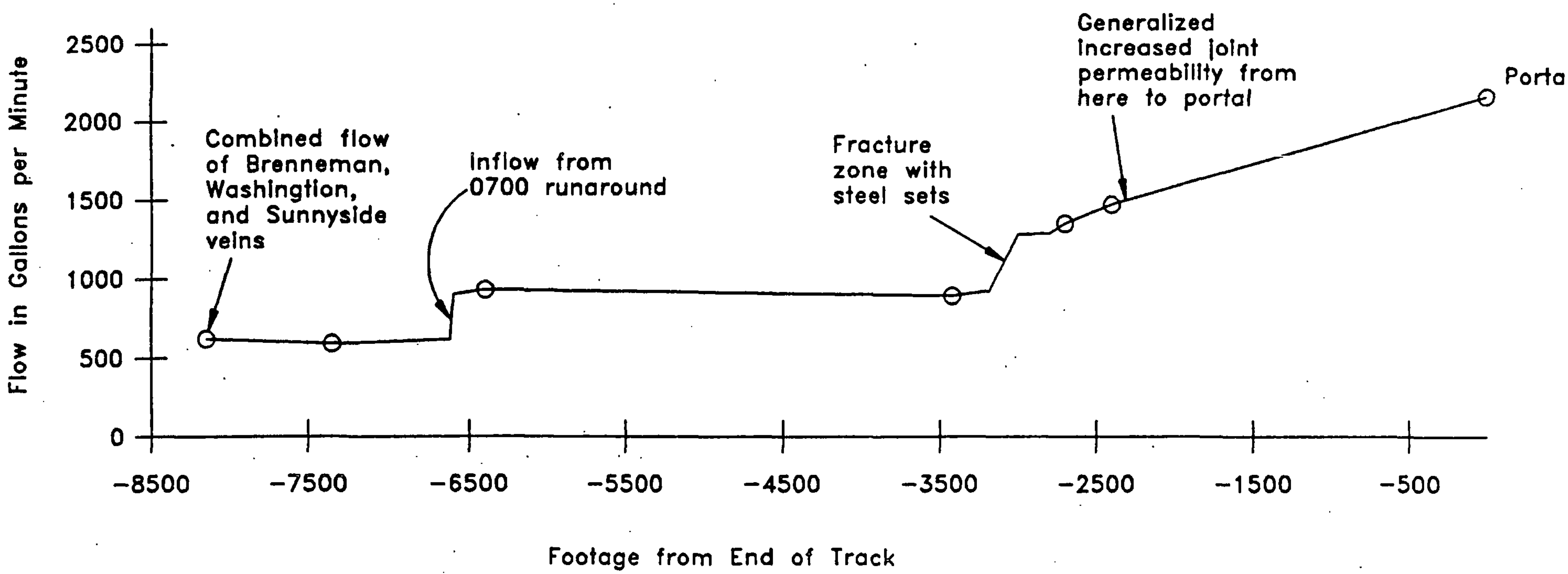
In the deeper parts of the American Tunnel (farther than approximately 2500 feet from the portal) the majority of water transmitted to the tunnel originates from a few fracture zones (Figure 10). Major permeable zones include the Washington vein (190 gpm), the Brenneman vein (200 gpm) the Sunnyside vein (180 gpm), a fracture zone at the 0700 runaround (approximately 340 gpm), and a fracture zone located 3020 to 3220 feet from the outside end of the track (approximately 400 gpm).

Within approximately 2500 feet of the portal minor joints transmit a significant amount of water. The increased permeability of the minor joints is due to a decrease in overburden pressure near the portal. This zone of generalized permeability accounts for approximately 32% of the flow leaving the portal.

On October 2-3, 1991 flow measurements showed 930 gpm of flow from the American Tunnel originated on SJCMV property. More than half (57%) of the discharge of the American Tunnel, amounting to 1230 gpm, entered the tunnel downstream of the property line.

4.2.2 Chemistry of Mine Waters

Most of the water entering the American Tunnel is ground water draining from fractures. This ground water locally contains relatively high concentrations of lead, zinc, cadmium, iron, and manganese. The chemistry of water entering the American Tunnel is discussed in further detail in section 3.1.5. Water discharging from the American Tunnel has a mean field pH value of 6.4, and a mean laboratory pH value of 5.4. Mean laboratory conductivity is 1,870 micro-mhos



EXPLANATION

○ Flow Measurement Points

NOTES

1. Footages are distance from end of track as marked on the wall of the American Tunnel and are approximate. The end of track is just outside of the American Tunnel portal.

2. Flow was measured with a pygmy flow meter by Evelyn Bingham and Guy Lewis of SJCMV on October 2-3, 1991.

San Juan County Mining Venture
Silverton, Colorado

Flow Profile Along the American Tunnel

DATE:	02/13/92
DRAWN:	KEK
CHECKED:	MJS
APPROVED:	[illegible]
DWG NO:	
PROJ.:	464110381

Hydro-Search, Inc.
HYDROLOGISTS-GEOLOGISTS-ENGINEERS

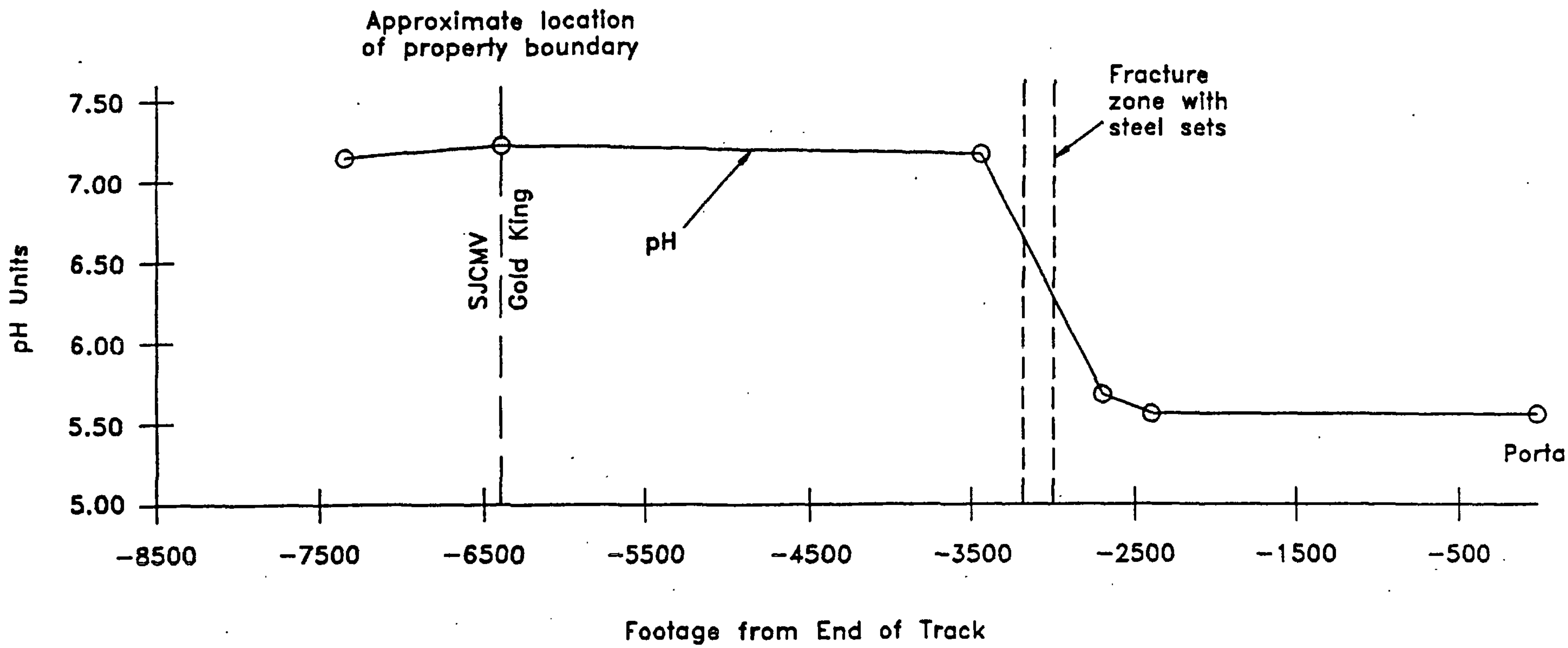
Figure 10

per centimeter. Mean values also indicate that the water has elevated concentrations (on a total metal basis) of cadmium, copper, iron, lead, manganese and zinc with respect to Colorado water quality standards (1986) for domestic water supplies.

The majority of the total metals load and the acid entering the American Tunnel originates downstream of the SJCMV property line. Figures 11, 12, and 13 are profiles of water chemistry along the American Tunnel. Figure 11 shows that on October 2 and 3, 1991 the flow in the American Tunnel had a nearly neutral pH until it encountered water entering from the fracture zone at the "steel sets" between 3020 and 3220 feet from the end of the track. Water from the steel sets fracture zone was sufficiently acidic to reduce the pH of the overall flow to approximately 5.5.

The total load of metals carried by a stream is the flow rate times the total metals concentrations. Figure 12 shows that the total metals load of iron, zinc, and manganese in American Tunnel ditch water dramatically increases after the steel sets fracture zone. The load of iron, zinc, and manganese continues to increase at a lesser rate throughout the last 2500 feet of the American Tunnel where dripping water enters the tunnel from relatively minor joints.

Figure 13 shows that the total metals load of copper and cadmium in American Tunnel ditch water also increases at the steel sets fracture zone. The load of cadmium does not increase downstream of this point, but the load of copper continues to increase in the last 2500 feet of the tunnel.



EXPLANATION

O Sample collection points

NOTES

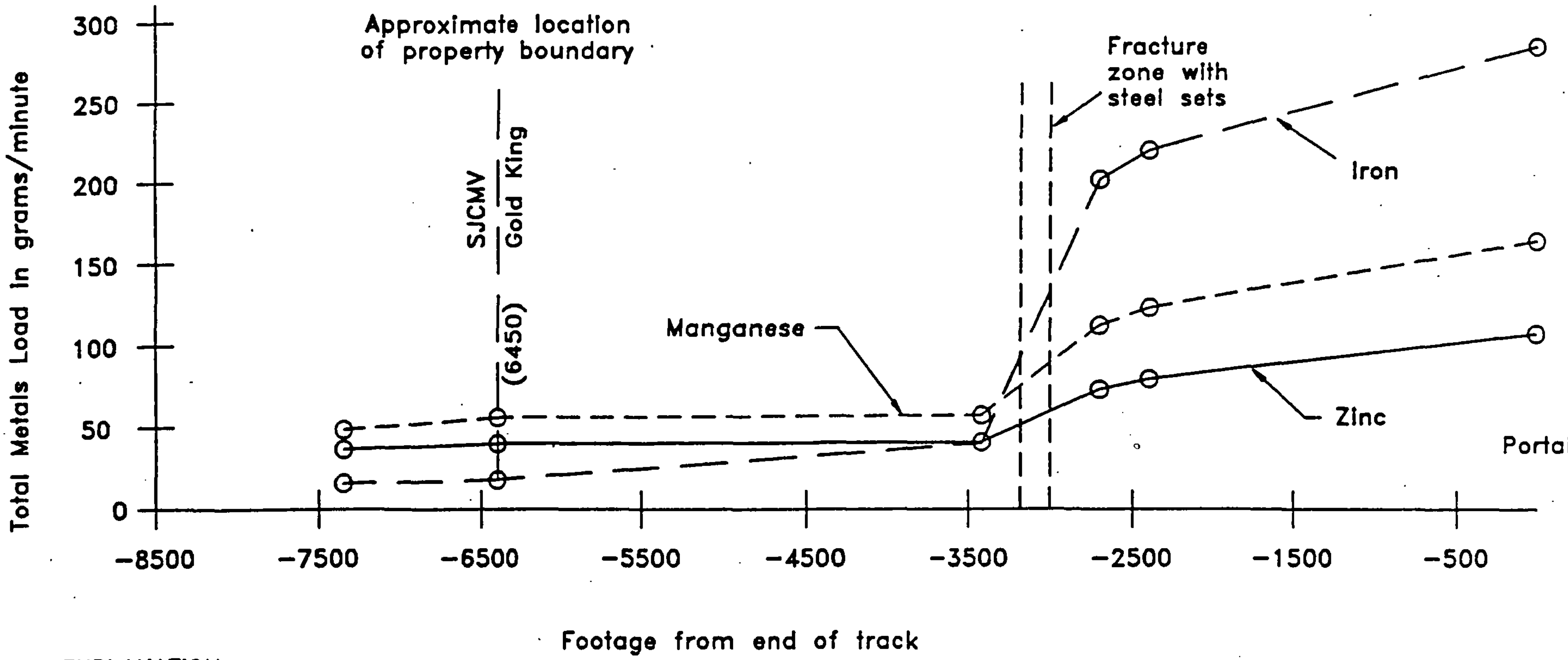
1. Footages are distance from end of track as marked on the wall of the American Tunnel and are approximate. The end of track is just outside of the American Tunnel portal.

2. Samples were collected by Evelyn Bingham and Guy Lewis of SJCMV on October 2-3, 1991.

3. Lab pH measured by Inter-Mountain Laboratories, Inc. of Farmington, NM.

San Juan County Mining Venture Silverton, Colorado	DATE: 01/21/92
	DRAWN: KEK
Profile of pH in the Drainage Ditch of the American Tunnel	CHECKED: MDS
	APPROVED:
	DWG NO:
	PROJ.: 464110361
Hydro-Search, Inc. HYDROLOGISTS-GEOLOGISTS-ENGINEERS Reno Denver Milwaukee Irvine	Figure 11

/usr4/san-juan/acad/464ah011.DWG



EXPLANATION

O Water Sampling Points

NOTES

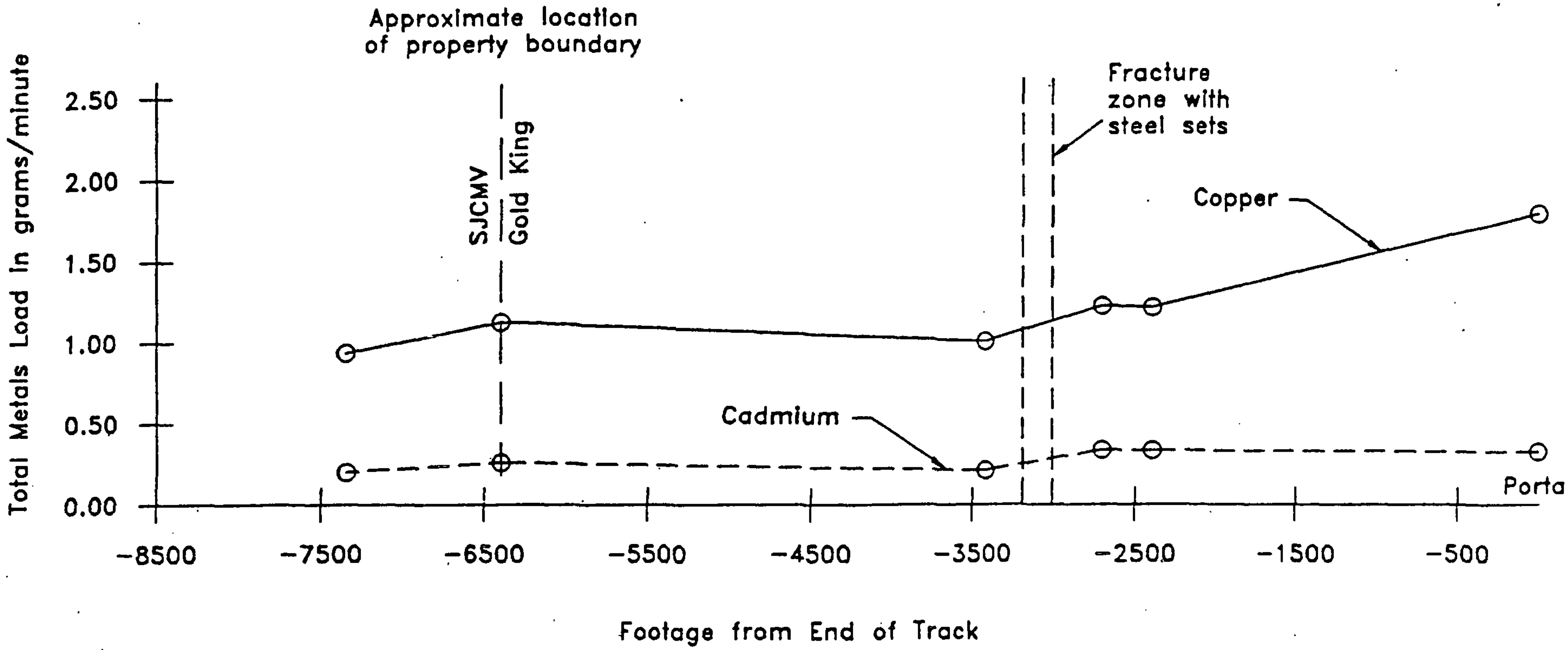
1. Footages are distance from end of track as marked on the wall of the American Tunnel and are approximate. The end of track is just outside of the American Tunnel Portal.

2. Samples were collected by Evelyn Bingham and Guy Lewis of SJCMV on October 2–3, 1991.

3. Analysis for total metals by Inter– Mountain Laboratories, Inc. of Farmington, NM.

San Juan County Mining Venture Silverton, Colorado	DATE: 01/21/92 DRAWN: KEK CHECKED: MDS APPROVED: J. Fox DWG NO: PROJ.: 464110361
Load of Mn, Fe, and Zn Carried in American Tunnel Ditch	
Hydro-Search, Inc. HYDROLOGISTS-GEOLOGISTS-ENGINEERS Reno Denver Milwaukee Irvine	Figure 12

/usr4/san-juan/acad/464sh009.DWG



EXPLANATION

O Water sampling points

NOTES

1. Footages are distance from end of track as marked on the wall of the American Tunnel and are approximate. The end of track is just outside of the American Tunnel portal.

2. Samples were collected by Evelyn Bingham and Guy Lewis of SJCMV on October 2-3, 1991.

3. Analysis for total metals by Inter-Mountain Laboratories, Inc. of Farmington, NM.

/usr4/san-juan/acad/464sh010.DWG

San Juan County Mining Venture Silverton, Colorado	DATE: 01/21/92
Load of Copper and Cadmium Carried in American Tunnel Ditch	DRAWN: KEK
	CHECKED: MJS
	APPROVED: J.Toy
	DWG NO:
	PROJ.: 464110361
Hydro-Search, Inc. HYDROLOGISTS-GEOLOGISTS-ENGINEERS Reno Denver Milwaukee Irvine	Figure 13

Water discharging from the Terry Tunnel is slightly acidic and contains elevated concentrations of some metals. The mean pH values for field and laboratory measurements are 5.9 and 5.7, respectively. However, the 1991 sampling shows a noticeable drop in the pH values. The mean values for total metal concentrations are all higher than the mean values for the American Tunnel with the exceptions of iron and manganese which were not analyzed.

Chemistry of the Terry Tunnel discharge water varies according to changes in surface water inflow to the upper levels of the mine. The rate of surface water inflow depends upon both daily and seasonal precipitation, and rate of snowmelt.

4.2.3 Existing Treatment Facilities - Sunnyside Mine

On Wednesday, July 31, 1991, Simon Hydro-Search was given a tour of the Sunnyside Mine's two lime precipitation systems at the American Tunnel and Terry Tunnel portals. Discharge from the American Tunnel is directed to a sump in the lime plant where lime is added to precipitate heavy metals. The tunnel discharge waters and the lime are allowed to mix in the turbulence created by the inflow to the sump. Discharge from the lime plant sump is by gravity flow to the first of four sedimentation ponds. None of the ponds are lined. A non-anionic polymer (Polypure N130) is added to the lime plant discharge somewhere in the 400 feet of pipeline between the sump and Pond No. 1. This addition of polymer facilitates the precipitation of heavy metals and has been accomplished by running a tube down the discharge pipe from the lime plant sump. However, the exact location of the tube end in the pipeline is unknown.

The discharge into Pond No. 1 is through a perforated pipe which runs along the east side of the pond. A brown sludge precipitates as water moves from east to west in Pond No. 1. The sludge settles out before it reaches the discharge pipe at the west end. The cleaning of Pond No. 1 occurs about every seven weeks and takes about one week to complete. Discharge is diverted to Pond No. 2 while Pond No. 1 is being cleaned. Pond No. 2 is cleaned once every year. All sludge is transported in tanker trucks to the tailings facility near the Mayflower Mill.

The discharge from Pond No. 4 is directed through a Parshall flume before it reaches Cement Creek. Flow rate and water quality samples are taken at the flume every week and reported to the Colorado Department of Health (CDH) once a month as required by the mine's NPDES permit. The rocks just below the flume outlet and the inside walls of the flume are coated with a black precipitate. This precipitate is probably derived from the manganese in the water which is not included in the treatment requirements of the mine's NPDES permit. For the last three years since the mine has been monitoring the treated discharge water from the American Tunnel, all discharge requirements have been met except for aquatic toxicity. The reason for the failure of the aquatic toxicity test is unknown. This is the prevailing condition throughout the Silverton Caldera including the water supply for Silverton.

Cement Creek is monitored for water quality and flow rate at two locations on a monthly basis pursuant to Colorado Mined Land Reclamation (MLR) requirements. The typical pH values at these two sites also are presented in Appendix C.

Discharge from the Terry Tunnel is highly variable and is dependent upon surface water inflow to mine workings from precipitation and snowmelt. Monitoring and treatment of the Terry Tunnel effluent is only conducted from late spring to early fall because the tunnel portal is inaccessible during the winter. Discharge from the Terry Tunnel is typically low during the winter months. Treatment consists of lime addition between the portal and the first of two sedimentation ponds. Pond No. 1 has been lined with recompacted fines. An "H" flume has been installed below Pond No. 2 for flow rate measurements. The NPDES discharge requirements for the Terry Tunnel effluent are less stringent than for the American Tunnel.

4.3 Present Surface-Water Hydrology

4.3.1 Surface-Water Flow

The measured flow rate (1987-1991) of the North Fork of Cement Creek just above Gladstone ranges between 15.7 mgd at the end of May to 0.23 mgd at the end of October (see Appendix C). Just below Gladstone this flow is augmented by the flow of the South Fork of Cement Creek which is not measured, and by the flow from the American Tunnel portal which is approximately 3.1 mgd (measured October 2-3, 1991).

The measured flow (1987-1991) of Eureka Creek above the Terry Tunnel portal varies from 5.2 mgd at the end of May to 0.05 mgd at the end of October. This flow is augmented by flow from the Terry Tunnel which ranges from 2.0 mgd in early June to 0.12 mgd in late October. The flow in Eureka Creek is also augmented by flow from McCarty Basin and downstream tributaries.

The measured flow in the Animas River (1986-1991) near the Mayflower Mill ranges from 116 mgd in April to 17.6 mgd in late October.

4.3.2 Surface-Water Chemistry

Present surface-water chemistry is influenced by the natural (pre-mining) surface-water chemistry as described in section 3.2.2, and the impacts of man, principally mining. The chemistry of the flows from the Terry Tunnel and American Tunnel is described in section 4.2.2. In addition to the workings of the Sunnyside Mine, there are numerous other mine workings which are not controlled by SJCMV located upstream of the Sunnyside portals including the Ben Franklin in Eureka Gulch, and the following mines in the Cement Creek watershed: the Big Colorado, Silver Ledge, Black Hawk, Gold King, Lead Carbonate, Red and Bonita, Adams, Pride of Bonita, Mogul, and Queen Anne.

The waters in Cement Creek and Eureka Creek have been sampled just above the American Tunnel and the Terry Tunnel, respectively, since 1987. The water of Cement Creek above the American Tunnel discharge is acidic, with pH values between 3 and 5 and a mean pH of 4.0. Natural ground-water seepage and mine drainage both contribute to this acidity; however, the percentage of each contribution would require additional sampling and analyses to quantify. The water of Eureka Creek above the Terry Tunnel discharge is neutral with a mean pH of 7.1.

5.0 REFERENCES CITED

Bird, A. G., 1986, Silverton Gold, The story of Colorado's Largest Gold Mine, 137 p.

British Columbia Acid Mine Drainage Task Force, 1989, Draft Acid Rock Drainage Technical Guide, Vol. 1.

Burbank, W.S.,1960, Pre-ore propylitization, Silverton Caldera, Colorado, U.S. Geol. Survey Prof. Paper 400-B, p. B12-B13.

Burbank, W.S., and Luedke, R.G., 1961, Origin and Evolution of Ore and Gangue-Forming Solutions, Silverton Caldera, San Juan Mountains, Colorado, *in* Short papers in geology and hydrology, U.S. Geol. Survey Prof. Paper 424-C, p. C7-C11.

Burbank, W.S., and Luedke, R.G., 1964, Geology of the Ironton Quadrangle, Colorado, U.S. Geol. Survey Geol. Quad. Map GQ-291.

Burbank, W.S., and Luedke, R.G., 1969, Geology and Ore Deposits of the Eureka and Adjoining Districts San Juan Mountains, Colorado, U.S. Geol. Survey Prof. Paper 535, 70 p.

Casadevall, T., and Ohmoto, H., 1977, Sunnyside Mine, Eureka mining district, San Juan County, Colorado: Geochemistry of gold and base metal ore deposition in a volcanic environment, Econ. Geology, v. 72, p. 1285-1320.

Driscoll, F.G., 1986, Groundwater and Wells, Second Edition, Johnson Division, St. Paul, Minnesota, 1089 p.

Freeze, R.A., and Cherry, J.A., 1979, Groundwater, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 604 p.

Garrells, R.M. and C.L. Christ, 1965, Solutions, Minerals, and Equilibria, Harper and Row, New York, 449 p.

Gebert, W.A., Graczyk, D.J., and Krug, W.R., 1987, Average Annual Runoff in the United States, 1951-80, Hydrologic Investigations Atlas HA-0710.

Iorns, W.V., Hembree, C.H., Phoenix, D.A., and Oakland, G.L., 1964, Water Resources of the Upper Colorado River Basin - Basic Data, U.S. Geol. Survey Prof. Paper 442, 1036 p.

Langbein, W.B., et al., 1949, Annual Runoff in the United States, U.S. Geol. Survey Circular 52, 14 p.

Langston, D.J., 1978, The Geology and Geochemistry of the Northeasterly Gold Veins, Sunnyside Mine, San Juan County, Colorado, Colorado School of Mines/M.S. thesis, 153 p.

Larsen E.S., and Cross, W., Geology and Petrology of the San Juan Region Southwestern Colorado, U.S. Geol. Survey Prof. Paper 258, 303 p.

Lohman, S.W., 1979, Ground-Water Hydraulics, U.S. Geol. Survey Prof. Paper 708, 70p.

Luedke, R.G., and Burbank, W.S., 1960, Ring-Fractured Bodies in the Silverton Caldera, Colorado, *in* Short papers in Geology and Hydrology, U.S. Geol. Survey Prof. Paper 400-B, p. B13.

Luedke, R.G. and Burbank, W.S., 1987, Geologic Map of the Handies Peak Quadrangle, San Juan, Hinsdale and Ouray Counties, Colorado, U.S. Geol. Survey Geol. Quad. Map GQ-1595.

Meiman, J.R. and Grant, L.O., 1974, Snow-Air Interactions and Management of Mountain Watershed Snowpack, Completion Report for OWRR Project No. B-073-COLO, Environmental Resources Center, Colorado State University, 33 p.

Rhoda, F., 1984, Summits to Reach: Report on the Topography of the San Juan Country, edited by Mike Foster, Pruett Publishing Company, Boulder, Colorado, 159 p.

Siskind, D.E. and R.R. Fumanti, 1974, Blast-Produced Fractures in Lithonia Granite, Report of Investigations 7901, U.S. Bureau of Mines, 38 p.

Steven, T.A., and Lipman, P.W., 1976, Calderas of the San Juan Volcanic Field, Southwestern Colorado, U.S. Geol. Survey Prof. Paper 958, 35 p.

Sunnyside Gold Corp.,1988, Structure and Ore Deposits of the Sunnyside Mine, Silverton, Colorado, in Epithermal Base-Metal and Precious-Metal Systems, San Juan Mountains, Colorado, Society of Economic Geologists, Guidebook Series Vol. 3.

Todd, D.K., 1980, Groundwater Hydrology, Second Edition, John Wiley & Sons, New York, 535 p.

Varnes, D.J., 1963, Geology and Ore Deposits of the South Silverton Mining Area, San Juan County, Colorado, U.S. Geol. Survey Prof. Paper 378-A, 53 p.

Worsey, P.N., 1985, Measurement of Blast Induced Damage in Wall Rock for a Selection of Underground Perimeter Blasting Techniques, in Proceedings of the Eleventh Conference on Explosives and Blasting Techniques, Society of Explosives Engineers, pp. 175-189.

Worsey, P.N., 1986, The Quantitative Assessment of Blast Damage in Highway Rock Cuts and Tunnel Profiles by Seismic Refraction Surveys, Rock Mechanics and Explosives Research Center, University of Missouri, Rolla, Missouri, 22 p.

APPENDIX A

Method of Estimating the Flow from a Drill Hole

Appendix A: Method of Estimating the Flow from a Drill Hole

Mr. Bob Ward (mine superintendent during construction of the American Tunnel) supplied the following estimates of conditions concerning the drill hole intersection of the Washington vein:

- The drill hole was approximately 4½ feet above the floor,
- The drill hole was 2 inches in diameter (BX bit),
- The hole was drilled at an upward angle of 7 to 8 degrees from the horizontal, and
- The water hit the floor approximately 20 feet from where it left the drill hole.

From the above information an estimate can be made of the rate of flow of water from the drill hole. The flow from the drill hole dropped to the floor due to 1) an initial downward component of velocity resulting from the angle of the drill hole, and 2) the acceleration of gravity.

The loss in elevation caused by the angle of the drill hole (assumed to be 7½ degrees) is :

$$\text{Elev.} = (20 \text{ feet}) \div \cos (7½ \text{ degrees}) = 2.63 \text{ feet}$$

Hence, the loss in elevation caused by the acceleration of gravity is:

$$4.5 \text{ feet} - 2.63 \text{ feet} = 1.87 \text{ feet},$$

where 4.5 feet is the initial height above the floor.

The time it takes for an object to drop 1.87 feet under the acceleration of gravity is calculated using the following equation:

$$\text{Distance} = \tfrac{1}{2}(\text{acceleration}) \times (\text{time})^2$$

or

$$1.87 \text{ feet} = \tfrac{1}{2}(32.2 \text{ feet/second}^2) \times t^2$$

$$t = 0.341 \text{ seconds}$$

The exit velocity is calculated as follows:

$$\text{Velocity} = [(20 \text{ feet}) \div (0.341 \text{ seconds})] \div \cos 7\tfrac{1}{2} \text{ degrees}$$

$$= 59.2 \text{ feet/sec}$$

The cross-sectional area of the drill hole is calculated as:

$$\text{Area} = \pi r^2 = \pi \times (1/12)^2 = 0.0218 \text{ feet}^2$$

The rate of flow is:

$$\text{Velocity} \times \text{Area} = 59.2 \text{ feet/sec} \times 0.0218 \text{ feet}^2 = 1.29 \text{ feet}^3\text{/second}$$

$$1.29 \text{ feet}^3\text{/sec} \times 60 \text{ sec/min} \times 7.48 \text{ gal/foot}^3 = 579 \text{ gallons/minute}$$

s value is only accurate to one significant figure and is better expressed as:

$$6 \times 10^2 \text{ gallons/minute}$$

APPENDIX B

Results of Permeability Testing of Clays Beneath Lake Emma

Lambert and Associates

CONSULTING GEOTECHNICAL ENGINEERS AND MATERIAL TESTING

August 22, 1988

Sunnyside Gold Corporation
P. O. Box 177
Silverton, CO 81433

PN: M88052MT

Attention: Mike Foutz

Subject: Permeability tests results for
Two (2) Sampled Delivered to our Laboratory

Mr. Foutz:

This letter presents the results of permeability tests performed on two (2) samples of material received in our laboratory on August 10, 1988. As your requested our laboratory tests included performing standard moisture-density relationship tests, ASTM Test Method D698, on each sample. The permeability tests were conducted in triaxial compressive strength tests chambers with a constant head. The permeability test samples were remolded to about 95 percent relative compaction at/or near optimum moisture content based on the moisture-density relationship test results. The results of the moisture-density tests and the permeability tests are attached. The test results were discussed with Mr. Larry Perino on August 19, 1988.

If you have any questions concerning the test results or if we may be of further assistance please contact us.

Respectfully submitted,

LAMBERT AND ASSOCIATES

Norman W. Johnston

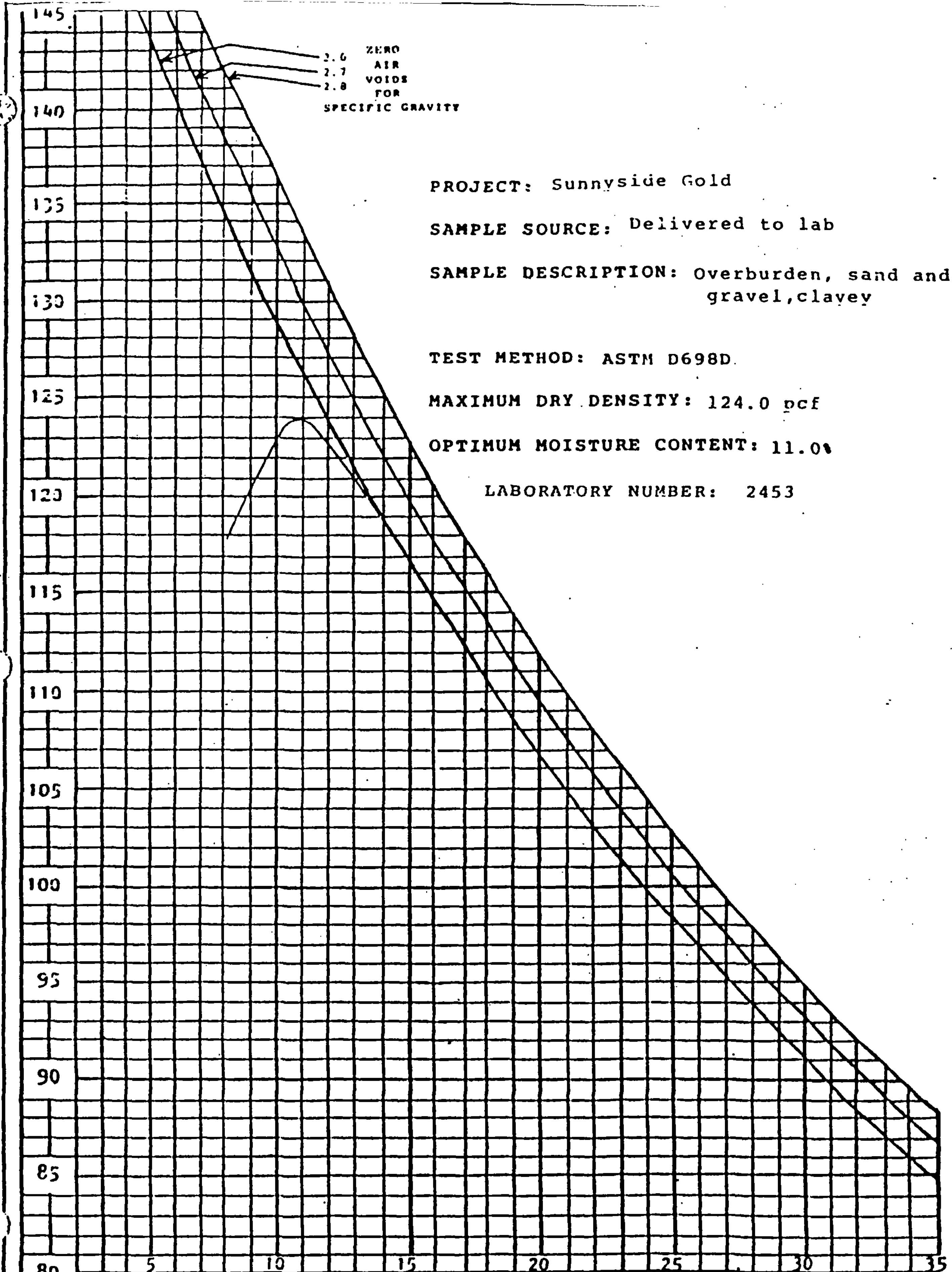
Norman W. Johnston, P.E.

attachments
NWJ/nr

P.O. BOX 3986
GRAND JUNCTION, CO 81502
(303) 245-6506

P.O. BOX 0045
MONTROSE, CO 81402
(303) 249-2154

463 TURNER, 104 A
DURANGO, CO 81301
(303) 259-5095



PROJECT: Sunnyside Gold

SAMPLE SOURCE: Delivered to lab

SAMPLE DESCRIPTION: Overburden, sand and gravel,clayey

TEST METHOD: ASTM D698D

MAXIMUM DRY DENSITY: 124.0 pcf

OPTIMUM MOISTURE CONTENT: 11.0%

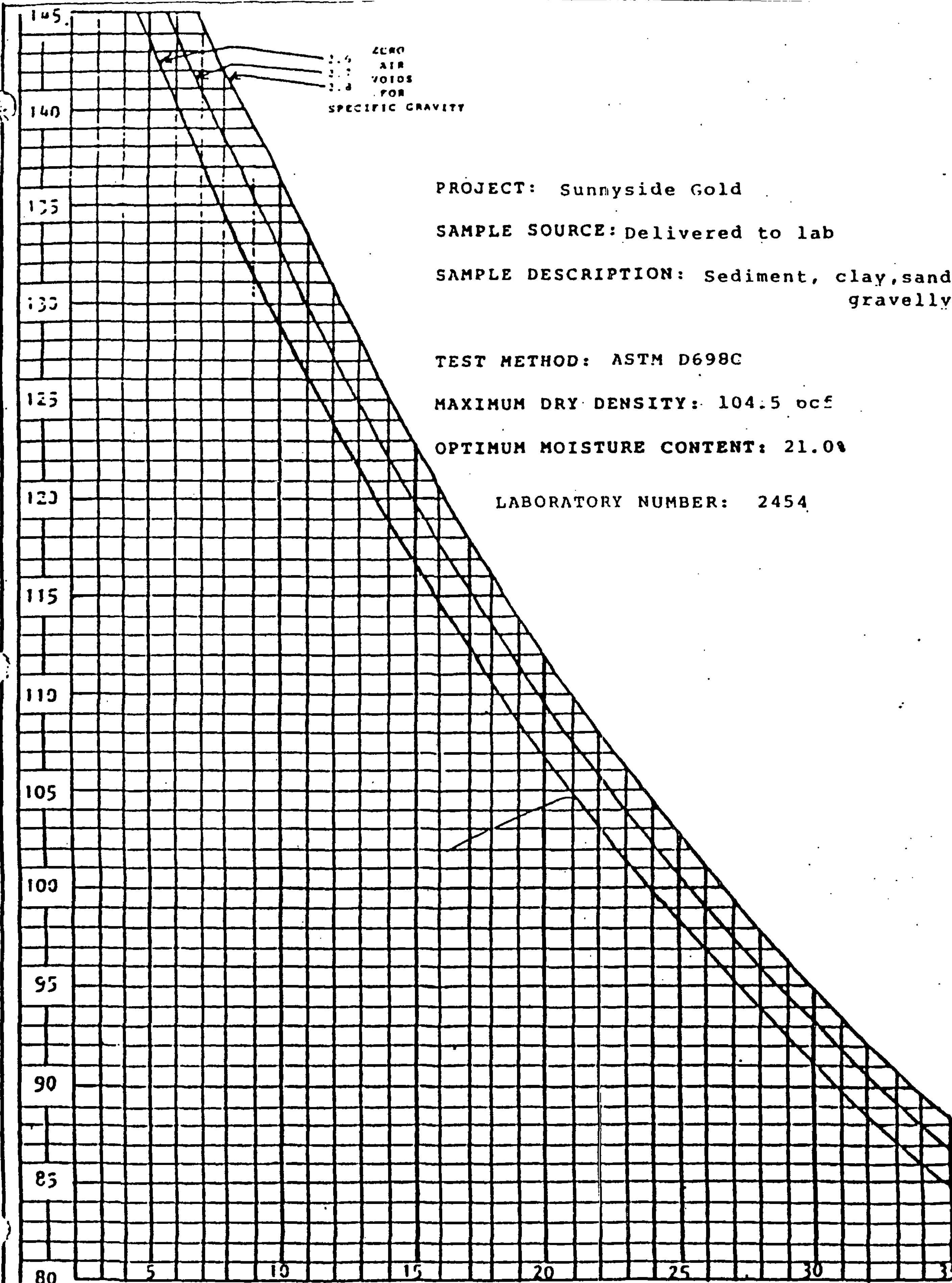
LABORATORY NUMBER: 2453

Lambert and Associates

Project No.: MC[illegible]052MT

Date:

Figure:



PROJECT: Sunnyside Gold

SAMPLE SOURCE: Delivered to lab

SAMPLE DESCRIPTION: Sediment, clay, sandy, gravelly

TEST METHOD: ASTM D698C

MAXIMUM DRY DENSITY: 104.5 pcf

OPTIMUM MOISTURE CONTENT: 21.0%

LABORATORY NUMBER: 2454

Lambert and Associates

Project No. M88052MT

Date:

Figure:

PERMEABILITY TEST RESULTS

Date: 8/15/88 Sample NO. 2453

Sample Description: Overburden-Sand and gravel, clayey

Permeability: 1.6×10^{-7} cm/sec

Date: 8/15/88 Sample NO. 2454

Sample Description: Sediment-Clay, sandy and gravelly

Permeability: 6.7×10^{-9} cm/sec

Lambert and Associates

CONSULTING GEOTECHNICAL ENGINEERS AND MATERIAL TESTING

TEST RESULTS

PROJECT Sunnyside Gold PROJECT NO. M88052MT DATE 8/10/88

LOCATION Silverton, CO SOURCE Delivered to lab

SAMPLE NO. 2453 & 2454 SPECIFICATION*

AFTER PERMEABILITY MOISTURE CONTENT

Sample Number: 2453

Moisture Content: 24.4%

Sand and gravel, clayey

Sample Number: 2454:

Moisture Content: 25.2%

Sand and gravel, clayey

APPENDIX C

Tables of Flow and Water Chemistry from the Sunnyside Mine

American Tunnel Discharge
(Before Treatment)

TABLE 1
San Juan County Mining Venture-Sunnyside Mine/Mayflower Mill
Water Data Summary Site: ATINFL*
Date Available thru:
08-Jul-91

Mean			2.273	6.4	5.4	10.5	1287	1870	1793	183	12	26	142	0.29	0.00	0.13	ERR	5.30
MAX			2.290	9.1	8.5	14.9	1750	2120	2230	1470	12	26	142	0.29	0.00	0.13	ERR	5.30
MIN			2.240	5.7	4.1	5.0	1000	1650	132	31	12	26	142	0.29	0.00	0.13	ERR	5.30

						C	uS	uS	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Station	Sampldate	lab	Qmgd	FieldpH	labpH	FieldT	FieldCond	labcond	TDS(180)	TSS	Hard Eff	TAlkCaCO	AcCaCo3	NO3&NO2	NO2	NH3-N	Cyanide	Fl
ATINFL	16-Mar-87	SGC																
ATINFL	31-Mar-87	SGC			6.43				1664	43.2								
ATINFL	02-Apr-87	SGC							1593									
ATINFL	16-Apr-87	SGC		6.3	6.46	10.9		1863	1658	49								
ATINFL	24-Apr-87	SGC		6.38	6.67	11.3		1700	1719	41.5								
ATINFL	28-Apr-87	SGC		6.07	6.68	11.6		1931	1718	90.5								
ATINFL	08-May-87	R&N		6.29	5.87	12.5		1897	1785	140.5								
ATINFL	15-May-87	R&N		6.23	5.92	13	1500		1970	120.5								
ATINFL	22-May-87	R&N		6.33	5.93	12.7	1220	1908	1780	69.2								
ATINFL	29-May-87	R&N		6.07	6.19	12	1400	1864	955	35.46								
ATINFL	10-Jun-87	IML		6.09	4.80	12.7	1400		1880	102								
ATINFL	16-Jun-87	IML		5.83	5.52	13.3	1390		1920	128								
ATINFL	23-Jun-87	IML		6	4.90	12.6	1450		1930	87								
ATINFL	30-Jun-87	IML		5.97	5.50	13.2	1450		1930	194								
ATINFL	07-Jul-87	IML		5.68	5.30	13.3	1550		1950	180								
ATINFL	24-Jul-87	IML		6.21	4.60	14.5	1400		2230	106								
ATINFL	15-Jul-87	IML		6.21	4.80	14	1300		1880	177								
ATINFL	30-Jul-87	IML		6.15	4.60	14	1000		1890	162								
ATINFL	06-Aug-87	IML		6.38	5.60	14.9	1380		1930	112								
ATINFL	11-Aug-87	IML		6.32	4.80	13.8	1400		1860	72								
ATINFL	18-Aug-87	IML		6.38	5.40	12.5			1910	82								
ATINFL	27-Aug-87	IML		6.19	4.90	11.8	1350		1890	180								
ATINFL	02-Sep-87	IML		6.2	4.30	10	1250	1860	1860	102								
ATINFL	12-Sep-87	IML		6.32	4.10	12	1250	1960	1830	148								
ATINFL	17-Sep-87	IML		6.3	4.60	11	1300	1950	1870	102								
ATINFL	01-Oct-87	IML		6.42	4.80	13.5		1880	1860	142								
ATINFL	07-Oct-87	IML		6.33	4.70	12		1930	1870	108								

ATINFL Table 1 p 1

						C	uS	uS	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Station	Sampldate	lab	Qmgd	FieldpH	labpH	FieldT	FieldCond	labcond	TDS(180)	TSS	Hard Eff	TAlkCaCO	AcCaCo3	NO3&NO2	NO2	NH3-N	Cyanide	Fl
ATINFL	16-Oct-87	IML		6.13	4.80	9		2120	1880	94								
ATINFL	23-Oct-87	IML		6.23	5.10	9		1950	1910	140								
ATINFL	30-Oct-87	IML		6.17	4.20	9.5		1880	1850	111								
ATINFL	13-Oct-87	IML		6.06		9.5												
ATINFL	21-Oct-87	IML		6.2		8.5												
ATINFL	27-Oct-87	IML		6.18		8.5												
ATINFL	06-Nov-87	IML		6.17	5.10	9.5		1890	1870	92								
ATINFL	13-Nov-87	IML		6.16	4.70	8.5		1750	1880	114								
ATINFL	22-Nov-87	IML		6.22	5.40	5		1720	1830	102								
ATINFL	27-Nov-87	IML		6.41	5.30	8		1650	1880	58								
ATINFL	04-Dec-87	IML		6.38		10												
ATINFL	03-Nov-87	IML		6.2		11												
ATINFL	11-Nov-87	IML		6.31		9.5												
ATINFL	17-Nov-87	IML		6.37		8.5												
ATINFL	04-Dec-87	IML		6.38	4.20	10		1840	1920	88								
ATINFL	11-Dec-87	IML		6.3	5.60	8.5	1200	1840	1920	66								
ATINFL	18-Dec-87	IML		6.21	5.40	8		1890	1880	124								
ATINFL	22-Dec-87	IML		6.38	4.50	9	1100	1840	1850	112								
ATINFL	31-Dec-87	IML		6.34	4.60	7		1840	1870	98								
ATINFL	02-Dec-87	IML		6.3		9												
ATINFL	09-Dec-87	IML		6.66		9												
ATINFL	16-Dec-87	IML		6.29		8												
ATINFL	13-Jan-88	IML		6.54	4.90	10			1910	104								
ATINFL	22-Jan-88	IML		6.33	5.60				1890	100								
ATINFL	29-Jan-88	IML		6.32	5.00				1850	160								
ATINFL	02-Feb-88	IML		6.22	5.90				1850	77								
ATINFL	05-Jan-88	IML		6.47		10												
ATINFL	26-Jan-88	IML		6.55														
ATINFL	11-Feb-88	IML		6.25	4.50	9.5			1910	192								
ATINFL	29-Feb-88	IML		6.55	5.9	10.5			1850	299								
ATINFL	10-Mar-88	IML		6.23	5.3	9	1100		1900	117								
ATINFL	22-Mar-88	IML		6.19	5.1	9.5			1890	176								
ATINFL	30-Mar-88	IML		6.3	4.9	8.5	1000		1910	277								
ATINFL	31-Mar-88	IML		6.59	5.2	9.5	1050		1890	416								
ATINFL	08-Apr-88	IML		6.45	6.2	11	1410		1900	880								
ATINFL	15-Apr-88	IML		6.22	4.9	5	1190		1870	248								

ATINFl Table 1 p 2

						C	uS	uS	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Station	Sampldate	lab	Qmgd	FieldpH	labpH	FieldT	FieldCond	labcond	TDS(180)	TSS	Hard Eff	TAlkCaCO	AcCaCo3	NO3&NO2	NO2	NH3-N	Cyanide	Fl
ATINFL	21-Apr-88	IML		6.24	5.7	9	1300		1880	170								
ATINFL	06-May-88	IML		6.28	5.70	8	1100		1900	316								
ATINFL	11-May-88	IML		6.52	5.3	11			1880	244								
ATINFL	16-May-88	IML		6.42	5.50	11			1920	358								
ATINFL	27-May-88	IML		6.4	4.90	10.5			1890	180								
ATINFL	13-May-88	IML		6.27		12												
ATINFL	24-May-88	IML		6.2		10												
ATINFL	31-May-88	IML		6.24		8.5												
ATINFL	03-Jun-88	IML		6.24	5.70	10.5			1910	128								
ATINFL	13-Jun-88	IML		6.22	5.70	10.5			1910	231								
ATINFL	20-Jun-88	IML		6.3		11												
ATINFL	21-Jun-88	IML		6.21		14												
ATINFL	24-Jun-88	IML		6.01	5.00	13			2010	902								
ATINFL	29-Jun-88	IML		6.15	5.20	12.5			1970	142								
ATINFL	15-Jul-88	IML		6.17	5.10	12			1990	372								
ATINFL	21-Jul-88	IML		6.53	5.50	12.5			1930	134								
ATINFL	29-Jul-88	IML		6.13	5.8	12			1970	101								
ATINFL	04-Aug-88	IML		6.21	5.30	11			1900	117								
ATINFL	10-Aug-88	NA		6.17														
ATINFL	12-Aug-88	IML		6.4	5.50	13			1920	1470								
ATINFL	16-Aug-88	IML		6.29	6.00	11			1940	103								
ATINFL	18-Aug-88	NA		6.31		11												
ATINFL	27-Aug-88	IML		6.3	5.10	12			850	82								
ATINFL	31-Aug-88	NA		6.33		11												
ATINFL	01-Sep-88	IML		6.61	5.40	11			132	186								
ATINFL	07-Sep-88	IML		6.45	4.60	8.5			1920	512								
ATINFL	09-Sep-88	NA		6.2														
ATINFL	14-Sep-88	IML		6.42	5.70	7			208	124								
ATINFL	23-Sep-88	NA		6.55		10												
ATINFL	23-Sep-88	IML		6.4	5.50	9			1890	75								
ATINFL	26-Sep-88	IML		6.4	6.00	9			1890	90								
ATINFL	29-Sep-88	NA		6.49		11												
ATINFL	06-Oct-88	NA		6.2		8												
ATINFL	04-Oct-88	IML		6.48	5.20	10			1840	200								
ATINFL	12-Oct-88	IML		6.52	4.80	10			1830	118								
ATINFL	14-Oct-88	NA		6.3		11.5												

ATINFL Tab. 1 of 3

						C	uS	uS	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Station	Sampldate	lab	Qmgd	FieldpH	labpH	FieldT	FieldCond	labcond	TDS(180)	TSS	Hard Eff	TAlkCaCO	AcCaCo3	NO3&NO2	NO2	NH3-N	Cyanide	Fl
ATINFL	18-Oct-88	IML		6.01	5	13.5			1860	188								
ATINFL	20-Oct-88	NA		6.04		10												
ATINFL	28-Oct-88	IML		6.17	5.10	9			1840	98								
ATINFL	02-Nov-88	NA		6.24		10												
ATINFL	04-Nov-88	IML		6.58	5.70				1780	148								
ATINFL	08-Nov-88	IML		6.33	5.7	9			1840	99								
ATINFL	11-Nov-88	NA		6.03		9												
ATINFL	16-Nov-88	NA		6.14		7.5												
ATINFLA	18-Nov-88	IML		6.18	5.00	9			1880	138								
ATINFLB	18-Nov-88	RN	2.28	9.12														
ATINFLB	18-Nov-88	RN	2.28	9.12														
ATINFL	22-Nov-88	IML		6.61	5.40	9			1880	98								
ATINFL	23-Nov-88	NA		6.64		10												
ATINFL	30-Nov-88	IML		6.71	5.9	10			1910	1420								
ATINFL	05-Dec-88	NA		6.6		9.5												
ATINFLA	06-Dec-88	IML		6.54	5.30	9.5			1820	145								
ATINFLB	06-Dec-88	CDS		6.54	5.73					71								
ATINFLC	06-Dec-88	RN		6.54	6.48					110								
ATINFLD	06-Dec-88	RN		6.54														
ATINFLA	13-Dec-88	IML		6.3	5.80	10			1840	134								
ATINFLB	13-Dec-88	RN		6.3	6.34					84.2								
ATINFLC	13-Dec-88	CDS		6.3	5.54					1290								
ATINFLA	19-Dec-88	IML		6.57	5.9	9			1840	92								
ATINFLB	19-Dec-88	RN		6.57	6.22					35.6								
ATINFLC	19-Dec-88	CDS		6.57	5.54					93								
ATINFL	21-Feb-89	IML		6.58	5.28	10			1858	268								
ATINFL	12-Apr-89	IML		6	5.7	8	1300		1636	139								
ATINFL	11-May-89	IML		6.66	5.8	12			1784	31								
ATINFL	12-Jun-89	IML		6.33	4.77	13	1300		134	42								
ATINFL	18-Jul-89	IML		6.51	5.93	12	1500		1892	132								
ATINFL	28-Aug-89	IML		6.33	5.42	14	1750		1844	86								

ATINFL Tab. 1 of 4

						C	uS	uS	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Station	Sampldate	lab	Qmgd	FieldpH	labpH	FieldT	FieldCond	labcond	TDS(180)	TSS	Hard Eff	TAlkCaCO	AcCaCo3	NO3&NO2	NO2	NH3-N	Cyanide	Fl
ATINFL	25-Sep-89	IML			5.53	11	1090		1858	84								
ATINFL	27-Oct-89	IML		6.64	6.14	12			1848	70								
ATINFL	30-Nov-89	IML		6.69	6.04	10	1400		1798	108								
ATINFL	29-Dec-89	IML		6.79	5.8	10			1850	82								
ATINFL	09-Jan-90	IML		6.72	5.42	10.0	1050		1878	90								
ATINFL	27-Feb-90	IML		6.53	5.36	11.0	1100		1866	72								
ATINFL	26-Mar-90	IML		6.2	5.8	11.0	1100		1874	108								
ATINFL	22-May-90	IML		6.34	5.82	12.0			1838	88								
ATINFL	25-Jun-90	IML		6.15	4.8	13.0			2002	108								
ATINFLA	10-Jul-90	IML		6.26														
ATINFLB	10-Jul-90	ACZ		6.26														
ATINFL	31-Jul-90	IML		6.59	5.35	12.0			1958	131								
ATINFL	27-Aug-90	IML		6.53	5.67	13.0			1960	96								
ATINFL	10-Sep-90	IML		6.49	8.52	12.0			1914	126								
ATINFL	25-Sep-90	RN		6.44		12												
ATINFL	23-Oct-90	IML		5.85	5.48				1890	78								
ATINFL	06-Nov-90	IML		6.61	5.98	7			860	446								
ATINFL	28-Nov-90	IML		6.23	5.19	8			1920	142								
ATINFL	15-Mar-91	IML		6.6	6.3	8.5			1910	80								
ATINFL	01-Apr-91		2.290															
ATINFL	01-Apr-91		2.240															
ATINFL	31-May-91	IML		6.3	5.6	10		1930	1234	113	12.4	25.9	142	0.29	<.04	0.13		5.3
ATINFL	10-Jun-91	IML		6.4		10												

ATINFl Table 1 p5

TABLE 2
San Juan County Mining Venture-Sunnyside Mine/Mayflower Mill
Water Data Summary METALS
Date Available thru: Site: ATINFL*
08-Jul-91

Mean	0.00	0.70	0.00	0.00	0.042	0.044	0.33	0.17	ERR	0.00	38.66	16.54	1.15	0.01	0.000	0.000	24.98	22.91	0.00	5.98	15.05	15.26
MAX	0.00	0.70	0.00	0.00	0.355	0.063	4.48	0.81	ERR	0.00	78.40	19.70	13.60	0.03	0.001	0.000	30.00	24.90	0.00	5.98	45.40	21.50
MIN	0.00	0.70	0.00	0.00	0.000	0.001	0.04	0.01	ERR	0.00	18.81	13.37	0.00	0.00	0.000	0.000	19.37	20.91	0.00	5.98	0.65	8.35
	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
StationSampldate	dAg	dAl	dTAs	dAu	TCadmium	dCd	TCopper	dCu	TCr	dCr	TFe3	dFe3	TLead	dPb	TMercury	dHg	TMn	dMn	dSe	dSr	TZinc	dZn
ATINFL 16-Mar-87															0.0004							
ATINFL 31-Mar-87					0.031		0.04				26.5		0.17		0.0009						9.88	
ATINFL 02-Apr-87															0.0003							
ATINFL 16-Apr-87					0.044		0.08				18.81		0.26		0.0003						9.46	
ATINFL 24-Apr-87					0.038		0.07				38.6		1.72		0.0005						10.18	
ATINFL 28-Apr-87					0.042		0.07				46.7		0.35		0.0002						8.89	
ATINFL 08-May-87					0.03		0.09						1.7		0.0003						10.05	
ATINFL 15-May-87					0.06		0.11						0.83		0.0004						19.37	
ATINFL 22-May-87					0.036		0.08						0.68		0.0002						12.59	
ATINFL 29-May-87					0.032		0.08						0.6		0.0003						12.9	
ATINFL 10-Jun-87					0.004		0.17						0.006		<.001						12.5	
ATINFL 16-Jun-87					0.061		0.51						<.02		<.001						18.6	
ATINFL 23-Jun-87					0.003		0.34						0.04		<.001						19.4	
ATINFL 30-Jun-87					0.066		0.7						1.52		<.001						20.1	
ATINFL 07-Jul-87					0.08		0.75						1.34		<.001						22.95	
ATINFL 24-Jul-87					0.049		0.25						0.49		<.001						13.76	
ATINFL 15-Jul-87					0.076		0.59						1.73		<.001						18	
ATINFL 30-Jul-87					0.046		0.21						0.13		<.001						15.2	
ATINFL 06-Aug-87					0.04		0.35						1.22		<.001						15.3	
ATINFL 11-Aug-87					0.04		0.17						0.37		<.001						13.2	
ATINFL 18-Aug-87					0.032		0.16						0.2		<.001						13.3	
ATINFL 27-Aug-87					0.047		0.25						1.3		<.001						14.58	
ATINFL 02-Sep-87					0.042		0.12						0.59		<.001						14	
ATINFL 12-Sep-87					0.045		0.14						1.21		<.001						14.3	
ATINFL 17-Sep-87					0.048		0.12						0.7		<.001						14.8	
ATINFL 01-Oct-87					0.044		0.19						1.76		<.001						14.6	
ATINFL 07-Oct-87					0.042		0.2						0.59		<.001						15.4	

ATINFL Table 2 p1

Station	Sampldate	dAg	dAl	dTAs	dAu	TCadmium	dCd	TCopper	dCu	TCr	dCr	TFe3	dFe3	TLead	dPb	TMercury	dHg	TMn	dMn	dSe	dSr	TZinc	dZn
-----------------		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
ATINFL	16-Oct-87					0.038		0.2						0.5		<.001						12.15	
ATINFL	23-Oct-87					0.042		0.22						0.85		<.001						14.06	
ATINFL	30-Oct-87					0.038		0.12						0.89		<.001						13.6	
ATINFL	13-Oct-87																						
ATINFL	21-Oct-87																						
ATINFL	27-Oct-87																						
ATINFL	06-Nov-87					0.039		0.08						0.47		<.001						13.4	
ATINFL	13-Nov-87					0.04		0.15						0.48		<.001						13.58	
ATINFL	22-Nov-87					0.04		0.09						0.31		<.001						13.14	
ATINFL	27-Nov-87					0.05		0.09						0.28		<.001						13.38	
ATINFL	04-Dec-87																						
ATINFL	03-Nov-87																						
ATINFL	11-Nov-87																						
ATINFL	17-Nov-87																						
ATINFL	04-Dec-87					0.009		0.12						<.02		<.001						13.2	
ATINFL	11-Dec-87					0.002		0.1						<.02		<.001						13	
ATINFL	18-Dec-87					0.083		0.09						<.02		<.001						12.8	
ATINFL	22-Dec-87					0.026		0.08						<.02		<.001						13.5	
ATINFL	31-Dec-87					0.011		0.05						0.06		<.001						13.8	
ATINFL	02-Dec-87																						
ATINFL	09-Dec-87																						
ATINFL	16-Dec-87																						
ATINFL	13-Jan-88					0.02		0.07						0.24		<.001						12.4	
ATINFL	22-Jan-88					0.008		0.06						0.16		<.001						12.9	
ATINFL	29-Jan-88					0.009		0.13						0.14		<.001						12.7	
ATINFL	02-Feb-88					0.009		0.06						<.02		<.001						12.2	
ATINFL	05-Jan-88																						
ATINFL	26-Jan-88																						
ATINFL	11-Feb-88					0.047		0.19						0.07		.001						14.7	
ATINFL	29-Feb-88					0.017		0.12						0.6		<.001						12.9	
ATINFL	10-Mar-88					0.015		0.16						0.04		<.001						13	
ATINFL	22-Mar-88					0.017		0.190						0.25		<.001						13.5	
ATINFL	30-Mar-88					0.015		0.13						0.32		<.001						13	
ATINFL	31-Mar-88					0.004		0.28						0.57		<.001						15.7	
ATINFL	08-Apr-88					0.065		0.55						1.21		<.001						20.3	
ATINFL	15-Apr-88					0.015		0.17						0.11		<.001						13.6	

ATINFl Table 7 p7

Station	Sampldate	dAg	dAl	dTAs	dAu	TCadmium	dCd	TCopper	dCu	TCr	dCr	TFe3	dFe3	TLead	dPb	TMercury	dHg	TMn	dMn	dSe	dSr	TZinc	dZn
		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
ATINFL	21-Apr-88					0.015		0.07						0.08		<.001						13.5	
ATINFL	06-May-88					0.033		0.2						0.44		<.001						14.3	
ATINFL	11-May-88					0.027		0.23						0.47		<.001						13.4	
ATINFL	16-May-88					0.134		2.32						9.06		<.001						26.7	
ATINFL	27-May-88					0.026		0.32						2.79		<.001						15.1	
ATINFL	13-May-88																						
ATINFL	24-May-88																						
ATINFL	31-May-88																						
ATINFL	03-Jun-88					0.052		0.41						2.58		<.001						16.9	
ATINFL	13-Jun-88					0.059		0.63						3.02		<.001						20.9	
ATINFL	20-Jun-88																						
ATINFL	21-Jun-88																						
ATINFL	24-Jun-88					0.061		2.03						8.11		<.001						34.2	
ATINFL	29-Jun-88					0.035		0.66						1.06		<.001						22.5	
ATINFL	15-Jul-88					0.040		0.8						3.52		<.001						43.3	
ATINFL	21-Jul-88					0.050		0.54						2.11		<.001						19.9	
ATINFL	29-Jul-88					0.046		0.2						0.3		<.001						11.8	
ATINFL	04-Aug-88					0.023		0.21						0.23		<.001						14.5	
ATINFL	10-Aug-88																						
ATINFL	12-Aug-88					0.027		0.34						1.56		<.001						8.24	
ATINFL	16-Aug-88					0.029		0.22						0.33		<.001						13.2	
ATINFL	18-Aug-88																						
ATINFL	27-Aug-88					0.032		0.12						0.07		<.001						12.3	
ATINFL	31-Aug-88																						
ATINFL	01-Sep-88					0.044		0.15						0.19		<.001						11.9	
ATINFL	07-Sep-88					0.276		1.38						0.62		<.001						39.2	
ATINFL	09-Sep-88																						
ATINFL	14-Sep-88					0.029		0.22						0.7		<.001						13.4	
ATINFL	23-Sep-88																						
ATINFL	23-Sep-88					0.039		0.17						0.25		<.001						11.8	
ATINFL	26-Sep-88					0.014		0.15						0.25		<.001						11.1	
ATINFL	29-Sep-88																						
ATINFL	06-Oct-88																						
ATINFL	04-Oct-88					0.040		0.18						1.03		<.001						14.4	
ATINFL	12-Oct-88					0.047		0.12						0.58		<.001						10.5	
ATINFL	14-Oct-88																						

ATINFL Table 2 p3

----------------- StationSampldate	mg/l dAg	mg/l dAl	mg/l dTAs	mg/l dAu	mg/l TCadmium	mg/l dCd	mg/l TCopper	mg/l dCu	mg/l TCr	mg/l dCr	mg/l TFe3	mg/l dFe3	mg/l TLead	mg/l dPb	mg/l TMercury	mg/l dHg	mg/l TMn	mg/l dMn	mg/l dSe	mg/l dSr	mg/l TZinc	mg/l dZn
ATINFL 18-Oct-88					0.030		0.27						1.1		<.001						22.8	
ATINFL 20-Oct-88																						
ATINFL 28-Oct-88					0.055		0.3						0.49		<.001						16	
ATINFL 02-Nov-88																						
ATINFL 04-Nov-88					0.028		0.14						0.97		<0.001						8.68	
ATINFL 08-Nov-88					0.044		0.19						0.99		<.001						8.9	
ATINFL 11-Nov-88																						
ATINFL 16-Nov-88																						
ATINFLA18-Nov-88					0.042		0.29						1.92		<0.001						11.4	
ATINFLB18-Nov-88					0.046		0.21						3.07		<0.001						14.27	
ATINFLB18-Nov-88					0.044		0.26						2.5		<0.001						13.47	
ATINFL 22-Nov-88					0.035		0.15						1.03		<0.001						10.4	
ATINFL 23-Nov-88																						
ATINFL 30-Nov-88					0.090		4.48						13.6		<.001						45.4	
ATINFL 05-Dec-88																						
ATINFLA06-Dec-88					0.041		0.14						0.84		<.001						12.5	
ATINFLB06-Dec-88																					12.7	
ATINFLC06-Dec-88					0.033		0.09						1.93								10.31	
ATINFLD06-Dec-88																					11.45	
ATINFLA13-Dec-88					0.035		0.31						0.63		<.001						12.9	
ATINFLB13-Dec-88					0.042		0.11						1.05								11.18	
ATINFLC13-Dec-88																					12.2	
ATINFLA19-Dec-88					0.024		0.12						0.17		<.001						8.21	
ATINFLB19-Dec-88					0.032		0.08						0.54								0.65	
ATINFLC19-Dec-88																					10.8	
ATINFL 21-Feb-89					0.015		0.340						1.606		<.001						14.11	
ATINFL 12-Apr-89					0.04		0.620						1.540		<.001						14.89	
ATINFL 11-May-89					<.002		0.12						0.71		<.01						10.7	
ATINFL 12-Jun-89					0.110		0.960						1.24		<.001						18.84	
ATINFL 18-Jul-89					0.043		0.390						1.42		<.001						15.62	
ATINFL 28-Aug-89					0.019		0.14						0.04		<.001						12.88	

ATINFL Table 7 p.4

------------------ StationSampldate	mg/l dAg	mg/l dAl	mg/l dTAs	mg/l dAu	mg/l TCadmium	mg/l dCd	mg/l TCopper	mg/l dCu	mg/l TCr	mg/l dCr	mg/l TFe3	mg/l dFe3	mg/l TLead	mg/l dPb	mg/l TMercury	mg/l dHg	mg/l TMn	mg/l dMn	mg/l dSe	mg/l dSr	mg/l TZinc	mg/l dZn
ATINFL 25-Sep-89					0.008		0.210						0.275		<.001						4.48	
ATINFL 27-Oct-89					0.02		0.13						0.02								11.12	
ATINFL 30-Nov-89					0.031		0.19						0.86		<.0002						12.33	
ATINFL 29-Dec-89					0.026		0.17						0.711		<.0002						11.63	
ATINFL 09-Jan-90					0.0390		0.190						1.012		<.0002						10.98	
ATINFL 27-Feb-90					0.0213		0.090	0.03					0.069	<.004	<.002						10.02	8.35
ATINFL 26-Mar-90					0.0276		0.260						4.270		<.0002						13.1	
ATINFL 22-May-90					0.0932		0.130						1.920								42	
ATINFL 25-Jun-90					0.0550	0.0616	0.810	0.81					1.105	0.028	<.0002	<.0002					24.2	20.5
ATINFLA10-Jul-90				<.05	0.3550	0.0630	0.89	0.12					1.550	0.006	<.0002	<.0002					22.9	21.5
ATINFLB10-Jul-90				0.002	0.0600		0.110						<.02								19	
ATINFL 31-Jul-90					0.0409		0.520						3.140		<.0002						14.3	
ATINFL 27-Aug-90					0.0230		0.340						0.513		<.002						13.8	
ATINFL 10-Sep-90					0.0130	0.0010	0.320	0.03					0.975	<.005	<.002	<.001					11.7	11.6
ATINFL 25-Sep-90											26.04						21.95					
ATINFL 23-Oct-90					0.0500		0.31						0.42		<.0002						16	
ATINFL 06-Nov-90					0.0718		0.69				78.4		4.41		<.001		30				22.2	
ATINFL 28-Nov-90					0.0267	0.0373	0.42	0.01			40.4	19.7	1.54	0.022	<.0002	<.0002	28.6	24.9			17.1	16.8
ATINFL 15-Mar-91					0.016		0.197						0.99		<.0002						12.50	
ATINFL 01-Apr-91																						
ATINFL 01-Apr-91																						
ATINFL 31-May-91	<.01	0.7	<.002	<.05	0.015	0.056	0.488	0.01		<.02	33.8	13.37	1.11	<.005	<.001	<.0002	19.37	20.91	<.002	5.98	12.89	12.78
ATINFL 10-Jun-91																						

ATINFl Table 2 p

TABLE 3
San Juan County Mining Venture-Sunnyside Mine/Mayflower Mill
Water Data Summary CAT/AN BAL
Date Available thru: Site: ATINFL*
08-Jul-91

Mean	0	0	1	1310	448	30	1	7	
MAX	0	0	1	1310	448	30	1	7	
MIN	0	0	1	1310	448	30	1	7	

-----------------	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	%
StationSampldate	bicarHCO	CO3	Chloride	Sulfate	Ca	Mg	K	Na	cat/andiff
ATINFL 25-Sep-89									
ATINFL 27-Oct-89									
ATINFL 30-Nov-89									
ATINFL 29-Dec-89									
ATINFL 09-Jan-90									
ATINFL 27-Feb-90									
ATINFL 26-Mar-90									
ATINFL 22-May-90									
ATINFL 25-Jun-90									
ATINFLA10-Jul-90									
ATINFLB10-Jul-90									
ATINFL 31-Jul-90									
ATINFL 27-Aug-90									
ATINFL 10-Sep-90									
ATINFL 25-Sep-90									
ATINFL 23-Oct-90									
ATINFL 06-Nov-90									
ATINFL 28-Nov-90									
ATINFL 15-Mar-91									
ATINFL 01-Apr-91									
ATINFL 01-Apr-91									
ATINFL 31-May-91	0	0	1.17	1310	448	29.8	0.75	6.9	0.11
ATINFL 10-Jun-91									

ATINFL Table 3

Terry Tunnel Discharge
(Before Treatment)

TABLE 1
San Juan County Mining Venture-Sunnyside Mine/Mayflower Mill
Water Data Summary   Site: TTINFL*
Date Available thru:
08-Jul-91

Station	Sampldate	lab	Qmgd	FieldpH	labpH	FieldT (C)	FieldCond (uS)	labcond (uS)	TDS(180) (mg/l)	TSS (mg/l)	Hard Eff (mg/l)	TAlkCaCO (mg/l)	AcCaCo3 (mg/l)	NO3&NO2 (mg/l)	NO2 (mg/l)	NH3-N (mg/l)	Cyanide (mg/l)	Fl (mg/l)
Mean				5.9	5.7	7.0	435	687	751	704	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR
MAX				6.8	6.8	11.0	910	868	1900	4600	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR
MIN				3.8	0.6	4.0	220	506	362	8	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR
TTINFL	05-Jun-87	R&N		5.69	6.04	6.2	342	506	370	278.6								
TTINFL	10-Jun-87	IML		5.53	6.50	6	320		394	1540								
TTINFL	16-Jun-87	IML		6.01	6.33	5.5	295		378	234								
TTINFL	25-Jun-87	IML		6.17	6.30	5.5	220		362	734								
TTINFL	01-Jul-87	IML		5.72	6.30	7.1	325		406	1220								
TTINFL	07-Jul-87	IML		5.98	6.40	7.5	315		366	678								
TTINFL	15-Jul-87	IML		6.43	6.40	8.5	330			4600								
TTINFL	24-Jul-87	IML		6.68	6.30	7	360		644	1760								
TTINFL	30-Jul-87	IML		6.16	6.20	6	375		420	190								
TTINFL	06-Aug-87	IML		6.19	6.20	5.5	315		506	200								
TTINFL	11-Aug-87	IML		6.04	6.70	5.2	360		498	120								
TTINFL	18-Aug-87	IML		6.45	6.30	7	550		748	86								
TTINFL	27-Aug-87	IML		6.15		6	515											
TTINFL	05-Sep-87	IML		6.1	6.20	6	520	868	732	62								
TTINFL	13-Apr-88	IML			5.9	8.5			1480	7.6								
TTINFL	27-May-88	IML		6.35	5.60	5			530	456								
TTINFL	03-Jun-88	IML		5.85	6.50	5			572	155								
TTINFL	13-Jun-88	IML		6.09	6.70	4			416	816								
TTINFL	24-Jun-88	IML		6.35	6.40	6			432	1780								
TTINFL	30-Jun-88	IML		5.98	6.30	5			452	972								
TTINFL	15-Jul-88	IML		6.03	6.00	9			656	284								
TTINFL	22-Jul-88	IML		5.87	5.60	5.5			660	210								
TTINFL	29-Jul-88	NA		6.36		9												
TTINFL	06-Aug-88	IML		6.78	5.90	7			732	2660								
TTINFL	12-Aug-88	IML		6.3	0.56	9			974	1980								
TTINFL	18-Aug-88	IML		5.92	6.10	11			896	116								
TTINFL	27-Aug-88	IML		6.05	5.60	10			1050	1420								

TTINFL Tabl. 1 p1

Station	Sampldate	lab	Qmgd	FieldpH	labpH	C FieldT	uS FieldCond	uS labcond	mg/l TDS(180)	mg/l TSS	mg/l Hard Eff	mg/l TAlkCaCO	mg/l AcCaCo3	mg/l NO3&NO2	mg/l NO2	mg/l NH3-N	mg/l Cyanide	mg/l Fl
TTINFL	01-Sep-88	IML		6.75	6.20	6			1900	2420								
TTINFL	07-Sep-88	IML		6.4	2.10	6			852	80								
TTINFL	15-Sep-88	IML		6.09	6.60	5.5			1850	1370								
TTINFL	23-Sep-88	IML		6.69	5.40				778	195								
TTINFL	26-Sep-88	IML		6.82	6.00	6			716	78								
TTINFL	05-Oct-88	NA																
TTINFL	12-Oct-88	IML		5.23	4.10	4			1110	8.4								
TTINFL	26-May-89	IML		6.83	6.4				434	89								
TTINFL	07-Jun-89	IML		6.31	5.64	9			498	85								
TTINFL	13-Jul-89	IML		6.45	6.51	7.5	410		606	393								
TTINFL	29-Aug-89	IML		4.92	4.69	9	910		1166	17								
TTINFL	26-Sep-89	IML		4.53	4.48	8	690		1118	37								
TTINFL	26-Oct-89	IML		5.16	4.81	5	680		916	15								
TTINFL	27-Jun-90	IML		6.36	6.75	5.0			632	139								
TTINFL	30-Jul-90	IML		5.9	5.4	5.0			908	157								
TTINFL	30-Aug-90	IML		6.23		9.0												
TTINFL	12-Sep-90	IML		5.99	5.22	9.0			1128	524								
TTINFL	06-Jun-91			4.5														
TTINFL	11-Jun-91	IML		5.6		10												
TTINFL	17-Jun-91	IML		4.4		9.9												
TTINFL	18-Jun-91			4.1														
TTINFL	20-Jun-91			5.2														
TTINFL	24-Jun-91			4.2		9												
TTINFL	01-Jul-91			3.8		8.6												

TTINFL Tabl. 1 of 2

TABLE 2
San Juan County Mining Venture-Sunnyside Mine/Mayflower Mill
Water Data Summary METALS
Date Available thru: Site: TTINFL*
08-Jul-91

-----------------	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
StationSampldate	dAg	dAl	dTAs	dAu	TCadmium	dCd	TCopper	dCu	TCr	dCr	TFe3	dFe3	TLead	dPb	TMercury	dHg	TMn	dMn	dSe	dSr	TZinc	dZn
Mean	ERR	ERR	ERR	ERR	0.138	0.201	2.63	0.92	ERR	ERR	ERR	ERR	4.81	0.51	0.000	0.000	ERR	ERR	ERR	ERR	32.69	40.90
MAX	ERR	ERR	ERR	ERR	0.397	0.289	29.00	1.30	ERR	ERR	ERR	ERR	26.40	0.65	0.003	0.000	ERR	ERR	ERR	ERR	65.35	52.00
MIN	ERR	ERR	ERR	ERR	0.002	0.113	0.15	0.53	ERR	ERR	ERR	ERR	0.00	0.37	0.000	0.000	ERR	ERR	ERR	ERR	6.32	29.80
TTINFL 05-Jun-87					0.056		0.74						2.49		0.0002						15.84	
TTINFL 10-Jun-87					0.003		1.64						19.5		<.001						20	
TTINFL 16-Jun-87					0.063		0.76						<.02		<.001						15.2	
TTINFL 25-Jun-87					0.002		1.14						0.23		<.001						19.5	
TTINFL 01-Jul-87					0.066		1.39						7.19		0.0010						19.7	
TTINFL 07-Jul-87					0.07		0.97						3.99		<.001						16.15	
TTINFL 15-Jul-87					0.138		3.85						26.4		<.001						33.17	
TTINFL 24-Jul-87					0.092		1.46						10.66		<.001						22.19	
TTINFL 30-Jul-87					0.077		0.15						0.17		<.001						16.9	
TTINFL 06-Aug-87					0.085		0.59						1.13		<.001						21.4	
TTINFL 11-Aug-87					0.084		0.57						0.76		<.001						20.7	
TTINFL 18-Aug-87					0.089		0.6						0.88		<.001						23.6	
TTINFL 27-Aug-87																						
TTINFL 05-Sep-87					0.119		0.55						0.99		<.001						31.6	
TTINFL 13-Apr-88					0.180		0.71						0.07		<.001						60.6	
TTINFL 27-May-88					0.058		1.38						3.78		<.001						20.9	
TTINFL 03-Jun-88					0.080		1.76						2.45		<.001						27.4	
TTINFL 13-Jun-88					0.030		2.04						4.17		<.001						27.1	
TTINFL 24-Jun-88					0.343		3.5						17.1		<.001						37.2	
TTINFL 30-Jun-88					0.134		4.21						26.3		<.001						46.1	
TTINFL 15-Jul-88					0.134		1.69						2.12		<.001						60.9	
TTINFL 22-Jul-88					0.120		1.47						1.11		<.001						38.6	
TTINFL 29-Jul-88																						
TTINFL 06-Aug-88					0.163		2.26						0.18		<.001						39.8	
TTINFL 12-Aug-88					0.397		6.18						22.9		<.001						64.18	
TTINFL 18-Aug-88					0.108		2.14						0.071		<.001						44.9	
TTINFL 27-Aug-88					0.274		3.56						3.13		<.001						62.2	

TTINFl Table 2 p 1

----------------		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Station	Sampldate	dAg	dAl	dTAs	dAu	TCadmium	dCd	TCopper	dCu	TCr	dCr	TFe3	dFe3	TLead	dPb	TMercury	dHg	TMn	dMn	dSe	dSr	TZinc	dZn
TTINFL	01-Sep-88					0.227		2.96						4.25		<.001						45.6	
TTINFL	07-Sep-88					0.039		0.18						0.31		<.001						12	
TTINFL	15-Sep-88					0.075		2.09						4.97		<.001						51.5	
TTINFL	23-Sep-88					0.190		1.23						0.96		<.001						34.9	
TTINFL	26-Sep-88					0.148		1.18						0.51		<.001						32.1	
TTINFL	05-Oct-88																						
TTINFL	12-Oct-88					0.373		29						0.68		<.001						42.8	
TTINFL	26-May-89					0.064		0.680						1.57		<.001						13.43	
TTINFL	07-Jun-89					0.100		1.320						1.35		0.0020						10.05	
TTINFL	13-Jul-89					0.125		1.330						1.55		0.0030						25.92	
TTINFL	29-Aug-89					0.258		4.630						0.74		<.001						65.35	
TTINFL	26-Sep-89					0.152		3.870						1.44		<.001						6.32	
TTINFL	26-Oct-89					0.129		2.170						0.15								31.5	
TTINFL	27-Jun-90					0.1275	0.1125	1.67	0.53					4.26	0.371	<.0002	<.0002					37	29.8
TTINFL	30-Jul-90					0.128		3.34						2.30		0.002						43.8	
TTINFL	30-Aug-90					0.2560		4.770						11.10		<.002						30	
TTINFL	12-Sep-90					0.2920	0.2890	2.100	1.3					3.12	0.646	<.002						52	52
TTINFL	06-Jun-91																						
TTINFL	11-Jun-91																						
TTINFL	17-Jun-91																						
TTINFL	18-Jun-91																						
TTINFL	20-Jun-91																						
TTINFL	24-Jun-91																						
TTINFL	01-Jul-91																						

TTINFL Table 2 p 2

Lake Emma Inflow to Mine

TABLE 1

San Juan County Mining Venture-Sunnyside Mine/Mayflower Mill

Water Data Summary Site: TT003*

Date Available thru:

08-Jul-91

Station	Sampldate	lab	Qmgd	FieldpH	labpH	C FieldT	uS FieldCond	uS labcond	mg/l TDS(180)	mg/l TSS	mg/l Hard Eff	mg/l TAlkCaCO	mg/l AcCaCo3	mg/l NO3&NO2	mg/l NO2	mg/l NH3-N	mg/l Cyanide	mg/l Fl
Mean			0.033	6.0	6.4	8.0	118	179	147	31	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR
MAX			0.144	7.3	7.7	15.0	205	183	840	478	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR
MIN			0.005	4.8	3.9	3.0	60	174	42	0	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR
TT003	25-Jun-87	IML		6	6.50	11.1	205		240	1								
TT003	15-Jul-87	IML	0.05	5.9	6.30	10	170		168	<1								
TT003	06-Aug-87	IML	0.04	5.66	6.80	6	130		146	<1								
TT003	12-Sep-87	IML	0.03	5.89	6.20	5.5	119	174	120	<.01								
TT003	06-Oct-87	IML	0.01	5.88	6.30	8		183	122	2								
TT003	24-Jun-88	IML		5.99	6.40	7.5			164	<.001								
TT003	15-Jul-88	IML		5.84	5.80	4			168	2								
TT003	31-Aug-88	IML	0.03	5.23	6.2	8			840	30								
TT003	26-Sep-88	IML	0.03	5.44	6.30	7			58	17								
TT003	12-Oct-88	IML	0.02	6.44	6.60	3			60	478								
TT003E	21-Jun-89	IML	0.02	6.81	7.7	7	85		62	0.4								
TT003W	21-Jun-89	IML	0.03	6.2	7.43	7	60		44	6								
TT003	25-Jul-89	IML	0.02	6.57	6.7	15			70	2								
TT003	29-Aug-89	IML	0.05	6.28	6.86	10.5	155		112	1								
TT003	26-Sep-89	IML	0.03	4.77	4.85	9	75		80	3								
TT003	13-Oct-89	IML	0.029	7.33	7.65	5			192	17								
TT003	25-Jul-90	IML	0.014	5.61	5.63	12.0			42	3								
TT003	20-Aug-90	IML	0.014	6.39	6.62	6.0			60	7								
TT003	19-Sep-90	IML	0.0050	5.78	3.86	10.0			48	14								
TT003	01-Jul-91	IML	0.144	6.8		7.6	60											

TT003 Table 1

TABLE 2
San Juan County Mining Venture-Sunnyside Mine/Mayflower Mill
Water Data Summary METALS
Date Available thru: Site: TT003*
08-Jul-91

------------------	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
StationSampldate	dAg	dAl	dTAs	dAu	TCadmium	dCd	TCopper	dCu	TCr	dCr	TFe3	dFe3	TLead	dPb	TMercury	dHg	TMn	dMn	dSe	dSr	TZinc	dZn
Mean	ERR	ERR	ERR	ERR	0.003	ERR	0.03	ERR	ERR	ERR	ERR	ERR	0.17	ERR	0.000	ERR	ERR	ERR	ERR	ERR	1.88	ERR
MAX	ERR	ERR	ERR	ERR	0.012	ERR	0.17	ERR	ERR	ERR	ERR	ERR	0.88	ERR	0.001	ERR	ERR	ERR	ERR	ERR	5.90	ERR
MIN	ERR	ERR	ERR	ERR	0.000	ERR	0.00	ERR	ERR	ERR	ERR	ERR	0.00	ERR	0.000	ERR	ERR	ERR	ERR	ERR	0.04	ERR
TT003 25-Jun-87					<.002		<.01						<.02		<.001						3.91	
TT003 15-Jul-87					0.006		0.02						<.02		<.001						3.57	
TT003 06-Aug-87					0.007		0.04						<.02		<.001						2.7	
TT003 12-Sep-87					0.008		<.01						<.02		<.001						2.62	
TT003 06-Oct-87					<.002		0.01						<.02		<.001						1.87	
TT003 24-Jun-88					0.012		0.03						<.002		<.001						3.76	
TT003 15-Jul-88					0.002		0.01						0.01		<.001						5.56	
TT003 31-Aug-88					0.007		0.01						0.37		<.001						2.02	
TT003 26-Sep-88					<.002		<.01						0.38		<.001						0.29	
TT003 12-Oct-88					<.002		0.09						0.06		<.001						0.49	
TT003E 21-Jun-89					<.002		<.01						0.01		<.001						0.04	
TT003W 21-Jun-89					0.008		0.030						0.18		<.001						0.55	
TT003 25-Jul-89					0.002		<.01						0.076		<.0002						0.68	
TT003 29-Aug-89					0.002		<.01						0.05		<.001						0.78	
TT003 26-Sep-89					<.002		0.170						0.44		<.001						0.31	
TT003 13-Oct-89					<.002		0.040						0.03		0.0010						5.9	
TT003 25-Jul-90					0.0004		0.010						0.555		<.0002						0.21	
TT003 20-Aug-90					0.0005		0.030						0.163		<.0002						0.21	
TT003 19-Sep-90					<.002		0.080						0.882		<.002						0.34	
TT003 01-Jul-91																						

TT003 Table 2

Animas River

TABLE 1
San Juan County Mining Venture-Sunnyside Mine/Mayflower Mill
Water Data Summary Site: AR3.*
Date Available thru:
09-Jul-91

Mean				7.7	7.3	7.7	168	264	164	4	129	28	0	0.40	ERR	0.17	0.00	0.63
MAX				8.5	7.9	12.0	300	371	302	21	168	34	0	2.55	ERR	0.90	0.00	1.49
MIN				6.7	6.4	2.0	110	197	58	0	86	19	0	0.01	ERR	0.00	0.00	0.31
						C	uS	uS	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Station	Sampldate	lab	Qmgd	FieldpH	labpH	FieldT	FieldCond	labcond	TDS(180)	TSS	Hard	Alk	Ac	NO3&NO2	NO2	NH3-N	Cyanide	Fl
AR3.5	01-Jul-86			7.7					85	1								
AR3.5	01-Aug-86			7.8					113	2							0.001	
AR3.5	01-Sep-86			7.5					117	7							0.004	
AR3.5	01-Oct-86			7.3					148	1	137			0.01		0.01	0.001	
AR3.5	02-Sep-87	IML	47.5	7.6	7.6	11.0	160.0	233	170	nd	105	32	nd	0.15		0.03		0.31
AR3.5	03-May-88	IML	38.4	7.9	7.0	8.0	120.0	260	166	3	115	26	nd	0.23		0.03	nd	0.4
AR3.5	18-Oct-88	IML	26.7	7.1	7.0			270	200	3	125	34	nd	2.55		0.90	nd	0.39
AR3.5	20-Apr-89	IML	115.9	7.9	6.4	9.0	150.0	218	58	2	93	19	nd	0.31		0.35	nd	0.39
AR3.5	16-May-89	IML	76.0	7.1	6.9	4.5	110.0	197	112	1	86	27	<1	0.31		0.1	<.005	0.52
AR3.5	30-Oct-89	IML	17.6	8.0	7.8	2.0	170.0	339	302	2	139	32	0	0.14		<.01	<.005	0.53
AR3.5	12-Mar-90	IML/ASnotmeas		8.2	7.0	2.0	300.0	371	272	6	168	31	0	0.16		0.199	<.005	0.528
AR3.5	04-May-90	IML	35.7	8.5	7.3	8.0	165.0	290	186	1	130	30	0	0.23		0.07	<.005	0.9
AR3.25	30-Jul-90	IML		7.7	7.9	12.0		230	192	5	112	23	0	0.39		0.08	<.005	0.67
AR3.5	30-Jul-90	IML		7.7	7.8	12.0		230	194	2	108	23	0	0.44		0.06	<.005	0.52
AR3.5	24-Sep-90	IML/THE									160							
AR3.5	30-Oct-90	IML	47.0	8.0	6.8	10.0		254	136	3	112	31	0	0.06		0.36	<.005	1.49
AR3.5	06-Dec-90	IML/THE		7.7	7.7						138							
AR3.5	11-Dec-90	IML/THE									138							
AR3.5	15-Jan-91	IML/THE									143							
AR3.5	24-Jan-91	IML/THE									157							
AR3.5	12-Mar-91	IML/THE									152							
AR3.5	30-Apr-91	IML/RN	35.1	6.7	7.8	5.9		274.0	172	21	124	32	0	0.19		<.04	<.01	0.91

AR3.5 Table 1

TABLE 2

San Juan County Mining Venture-Sunnyside Mine/Mayflower Mill

Water Data Summary METALS

Date Available thru: Site: AR3.*

09-Jul-91

Station	Sampldate	dAg	dAl	dAs	dAu	TCd	dCd	TCu	dCu	TCr	dCrT	TFe	dFeIII	TPb	dPb	THg	dHg	TMn	dMn	dSe	dSr	TZn	dZn
Mean		0.00	0.04	0.00	0.00	0.004	0.002	0.02	0.01	ERR	0.00	ERR	0.06	0.08	0.00	0.000	0.000	ERR	0.24	0.00	0.40	0.27	0.43
MAX		0.00	0.40	0.05	0.00	0.006	0.006	0.03	0.04	ERR	0.00	ERR	0.35	0.25	0.03	0.000	0.000	ERR	0.49	0.00	0.41	0.42	0.98
MIN		0.00	0.00	0.00	0.00	0.001	0.000	0.01	0.00	ERR	0.00	ERR	0.00	0.01	0.00	0.000	0.000	ERR	0.00	0.00	0.38	0.16	0.17
		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
AR3.5	01-Jul-86					0.001		0.01						0.25		0.00036						0.16	
AR3.5	01-Aug-86					0.004		0.025						0.015		0.0001						0.18	
AR3.5	01-Sep-86					0.006		0.033						0.063		0.00039						0.417	
AR3.5	01-Oct-86					0.004		0.02						0.01		0.00033						0.31	
AR3.5	02-Sep-87	nd	nd	nd			0.002		nd		nd		nd		nd		nd		0.35	nd			0.37
AR3.5	03-May-88	nd	nd	nd			nd		nd		nd		nd		nd		nd		0.3	nd			0.49
AR3.5	18-Oct-88	nd	nd	nd			nd		0.04		nd		0.35		0.03		nd		0.18	nd			0.29
AR3.5	20-Apr-89	nd	0.1	nd			0.006		0.01		nd		0.12		nd		nd		0.49	nd			0.98
AR3.5	16-May-89	<.01	<.01	0.049			0.002		<.01		<.02		0.11		<.02		<.001		0.26	<.005			0.5
AR3.5	30-Oct-89	nd	0.4	nd			0.002		0.01		nd		0.16		nd		nd		nd	nd			0.17
AR3.5	12-Mar-90	nd	nd	0.0006			0.0027		nd		nd		nd		0.005		nd		0.22	nd			0.42
AR3.5	04-May-90	nd	nd	nd			0.0015		nd		nd		nd		nd		nd		0.23	nd			0.48
AR3.25	30-Jul-90	<.01	<.1	0.0003			0.0014		<.01		<.02		<.05		0.019		<.0002		0.14	<.0002			0.27
AR3.5	30-Jul-90	<.01	<.1	0.0009			0.0013		<.01		<.02		<.05		<.004		0.0002		0.14	<.0002			0.27
AR3.5	24-Sep-90																						
AR3.5	30-Oct-90	<.01	<.1	0.0008	<.05		0.0016		<.01		<.02		<.05		<.004		<.001		0.38	0.000	0.38		0.45
AR3.5	06-Dec-90																						
AR3.5	11-Dec-90																						
AR3.5	15-Jan-91																						
AR3.5	24-Jan-91																						
AR3.5	12-Mar-91																						
AR3.5	30-Apr-91	<.01	<.1	<.005	<.05		0.0007		<.01		<.02		<.05		<.005		<.001		0.21	<.005	0.41		0.46

AR3 ← Table 7

TABLE 3
San Juan County Mining Venture-Sunnyside Mine/Mayflower Mill
Water Data Summary CAT/AN BAL
Date Available thru: Site: AR3.*
09-Jul-91

Mean		34	0	2	88	42	3	1	2	
MAX		41	0	4	137	61	7	2	3	
MIN		23	0	0	56	26	0	0	1	

-----------------		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	%
Station	Sampldate	Bicarb	CO3	Chloride	Sulfate	Ca	Mg	K	Na	cat/andiff
AR3.5	01-Jul-86									
AR3.5	01-Aug-86									
AR3.5	01-Sep-86									
AR3.5	01-Oct-86									
AR3.5	02-Sep-87	39	0	0	70	41	0	nd	2	1.88
AR3.5	03-May-88	31	0	2	80	44	1	nd	2	1.06
AR3.5	18-Oct-88	41	0	nd	90	47	2	1	2	0.77
AR3.5	20-Apr-89	23	0	0	70	26	7	0	2	2.1
AR3.5	16-May-89	27	0	3	56	32	1	1	1	1.1
AR3.5	30-Oct-89	38.65	0	0	109.05	50.53	3.13	0.88	2.5	1.43
AR3.5	12-Mar-90	37.28	0	3.21	136.62	60.64	4.16	0.84	2.7	0.73
AR3.5	04-May-90	36.1	0	0.5	99.2	46.2	3.5	1.5	2.1	0.56
AR3.25	30-Jul-90	28	0	2.1	85.6	38.6	4	1.5	2.1	1.04
AR3.5	30-Jul-90	28	0	4.2	86	40.2	2	1.6	2.4	1.84
AR3.5	24-Sep-90									
AR3.5	30-Oct-90	37.8	0	4.08	79.4	36.9	4.93	0.52	1.7	1.13
AR3.5	06-Dec-90									
AR3.5	11-Dec-90									
AR3.5	15-Jan-91									
AR3.5	24-Jan-91									
AR3.5	12-Mar-91									
AR3.5	30-Apr-91	38.4	0	3.04	94	43.1	3.92	0.63	2.3	1.65

TABLE 4
San Juan County Mining Venture-Sunnyside Mine/Mayflower Mill
Water Data Summary BIOMONITORING DATA
Date Available thru: Site: AR3.*
09-Jul-91

Station	Sampldate	LC50 FHM	%SURV FHM100%	LC50 Cerio	%SURV Cerio100%	mg/l ReconHard	mg/l ReconCond	mg/l ReconAlk	mg/l RcvHard	mg/l EFFHard	mg/l EFFAlk	mg/l EFFCon	mg/l EFFAmm	mg/l EFFCl	Date strt	Time strt	pH strt	pH end
Mean			100		3	291	980	198	ERR	136	116	ERR	145.00	0.00				
MAX			100		5	306	980	198	ERR	136	200	ERR	290.00	0.00				
MIN			100		0	275	980	198	ERR	136	32	ERR	0.00	0.00				
AR3.5	01-Jul-86																	
AR3.5	01-Aug-86																	
AR3.5	01-Sep-86																	
AR3.5	01-Oct-86																	
AR3.5	02-Sep-87																	
AR3.5	03-May-88																	
AR3.5	18-Oct-88																	
AR3.5	20-Apr-89																	
AR3.5	16-May-89																	
AR3.5	30-Oct-89																	
AR3.5	12-Mar-90	>100	100	24	5	306.00	980				200		290	<.02				
AR3.5	04-May-90																	
AR3.25	30-Jul-90																	
AR3.5	30-Jul-90																	
AR3.5	24-Sep-90																	
AR3.5	30-Oct-90																	
AR3.5	06-Dec-90																	
AR3.5	11-Dec-90																	
AR3.5	15-Jan-91																	
AR3.5	24-Jan-91																	
AR3.5	12-Mar-91																	
AR3.5	30-Apr-91				0	275		198		136	32		ND	ND				

AR 3.5 Table 4

Boulder Creek Above

TABLE 1
San Juan County Mining Venture-Sunnyside Mine/Mayflower Mill
Water Data Summary Site: BC1*
Date Available thru:
09-Jul-91

Station	Sampldate	lab	Qmgd	FieldpH	labpH	FieldT	FieldCond	labcond	TDS(180)	TSS	Hard	Alk	Ac	NO3&NO2	NO2	NH3-N	Cyanide	Fl
Mean				7.3	7.3	9.0	70	134	77	5	67	25	0	0.14	ERR	0.06	0.00	0.86
MAX				8.2	7.8	24.0	90	168	202	13	93	34	0	0.25	ERR	0.37	0.00	3.21
MIN				6.6	6.9	2.0	38	94	26	0	52	19	0	0.01	ERR	0.00	0.00	0.23
						C	uS	uS	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
BC1	01-Jul-86	SGC		6.68		15			34	1								
BC1	01-Sep-86	SGC		7.29		24			54	3								
BC1	01-Oct-86	SGC		6.77		17			65	13				0.01		0.01	0.001	
BC1	28-Oct-88	IML	0.82	8.24	7.1	3.5		155	104	12	79	34	nd	0.14		0.37	nd	0.23
BC1	26-Apr-89	IML	5.23	7.25	6.9	2	38	94	26	7	93	19	nd	0.17		nd	nd	0.39
BC1	30-Oct-89	IML	1.17	7.39	6.9	2.5	90	168	202	2	63	28	0	0.21		<.01	<.005	0.27
BC1	04-May-90	IML	1.89	7.99	7.5	3.2	83	122	74	<.5	52	21	0	0.25		<.02	<.005	0.42
BC1	30-Oct-90	IML	2.00	7.83	7.8	7.5		118	42	3	60	27	0	0.06		0.07	<.005	3.21
BC1	30-Apr-91	IML/RN	1.22	6.58	7.6	6.2		149	94	2	55	24	0	0.14		<.04	<.01	0.63

BC1 Table 1

TABLE 2
San Juan County Mining Venture-Sunnyside Mine/Mayflower Mill
Water Data Summary   METALS
Date Available thru: Site: BC1*
09-Jul-91

Station	Sampldate	dAg	dAl	dAs	dAu	TCd	dCd	TCu	dCu	TCr	dCrT	TFe	dFeIII	TPb	dPb	THg	dHg	TMn	dMn	dSe	dSr	TZn	dZn
Mean		0.00	0.05	0.00	0.00	0.017	0.001	0.02	0.01	ERR	0.00	ERR	0.08	0.02	0.01	0.001	0.000	ERR	0.06	0.00	0.19	0.11	0.05
MAX		0.00	0.10	0.00	0.00	0.030	0.002	0.03	0.02	ERR	0.00	ERR	0.49	0.05	0.08	0.003	0.000	ERR	0.34	0.00	0.20	0.14	0.10
MIN		0.00	0.00	0.00	0.00	0.010	0.000	0.01	0.00	ERR	0.00	ERR	0.00	0.01	0.00	0.000	0.000	ERR	0.00	0.00	0.18	0.10	0.00
-----------------		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
BC1	01-Jul-86					0.010		0.01						0.01		0.00						0.10	
BC1	01-Sep-86					0.030		0.03						0.05		0.00						0.14	
BC1	01-Oct-86					0.010		0.01						0.01		0.00						0.10	
BC1	28-Oct-88	nd	0.10	nd			0.002		0.01		nd		0.49		0.08		nd		0.34	nd			0.10
BC1	26-Apr-89	nd	0.10	nd			nd		0.01		nd		nd		nd		nd		nd	nd			0.09
BC1	30-Oct-89	nd	nd	nd			0.002		nd		nd		.06		nd		nd		nd	nd			nd
BC1	04-May-90	nd	nd	nd			0.000		0.02		nd		nd		nd		nd		nd	nd			0.04
BC1	30-Oct-90	<.01	<.1	0.001	<.05		<.0002		<.01		<.02		<.05		<.004		<.001		<.02	<.0002	0.18		0.03
BC1	30-Apr-91	<.01	0.10	<.005	<.01		<.0005		<.01		<.02		<.05		<.005		<.005		<.02	<.005	0.20		0.04

P1 Table 2

TABLE 3
San Juan County Mining Venture-Sunnyside Mine/Mayflower Mill
Water Data Summary CAT/AN BAL
Date Available thru: Site: BC1*
09-Jul-91

Mean		31	0	2	29	21	1	1	1	
MAX		41	0	6	40	28	2	1	2	
MIN		23	0	0	13	12	1	0	0	
		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	%
Station	Sampldate	Bicarb	CO3	Chloride	Sulfate	Ca	Mg	K	Na	cat/andiff
BC1	01-Jul-86									
BC1	01-Sep-86									
BC1	01-Oct-86									
BC1	28-Oct-88	41.0	0.0	2.0	40.0	28.0	2.0	nd	2.0	2.5
BC1	26-Apr-89	23.0	0.0	0.0	13.0	12.0	1.0	1.0	0.0	3.3
BC1	30-Oct-89	33.8	0.0	0.0	36.6	24.4	0.5	0.7	1.4	1.3
BC1	04-May-90	25.6	0.0	1.4	31.9	19.3	1.0	1.4	0.9	1.0
BC1	30-Oct-90	33.6	0.0	6.1	25.5	20.9	2.0	0.3	0.9	0.2
BC1	30-Apr-91	28.7	0.0	3.0	28.6	20.1	1.2	0.4	1.7	0.8

TABLE 4
San Juan County Mining Venture-Sunnyside Mine/Mayflower Mill
Water Data Summary BIOMONITORING DATA
Date Available thru: Site: BC1*
09-Jul-91

Station	Sampldate	LC50 FHM	%SURV FHM100%	LC50 Cerio	%SURV Cerio100%	mg/l ReconHard	mg/l ReconCond	mg/l ReconAlk	mg/l RcvHard	mg/l EFFHard	mg/l EFFAlk	mg/l EFFCon	mg/l EFFAmm	mg/l EFFCl	Date strt	Time strt	pH strt	pH end
Mean			ERR		10	275	ERR	198	ERR	56	32	ERR	0.00	0.00				
MAX			ERR		10	275	ERR	198	ERR	56	32	ERR	0.00	0.00				
MIN			ERR		10	275	ERR	198	ERR	56	32	ERR	0.00	0.00				
BC1	01-Jul-86																	
BC1	01-Sep-86																	
BC1	01-Oct-86																	
BC1	28-Oct-88																	
BC1	26-Apr-89																	
BC1	30-Oct-89																	
BC1	04-May-90																	
BC1	30-Oct-90																	
BC1	30-Apr-91			TOX	10	275		198		56	32		ND	ND				

BC1 Table 4

Cement Creek
(above Mine)

TABLE 1
San Juan County Mining Venture-Sunnyside Mine/Mayflower Mill
Water Data Summary Site: CC1*
Date Available thru:
08-Jul-91

Station	Sampldate	lab	Qmgd	FieldpH	labpH	FieldT	FieldCond	labcond	TDS(180)	TSS	Hard	Alk	Ac	NO3&NO2	NO2	NH3-N	Cyanide	Fl
Mean				4.3	4.0	8.2	263	410	320	21	174	0	40	0.24	ERR	0.07	0.00	1.26
MAX				6.1	5.2	19.5	1000	1060	945	104	518	4	166	0.62	ERR	0.64	0.02	4.79
MIN				3.2	3.1	0.0	110	168	62	1	43	0	1	0.00	ERR	0.00	0.00	0.07
						C	uS	uS	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Station	Sampldate	lab	Qmgd	FieldpH	labpH	FieldT	FieldCond	labcond	TDS(180)	TSS	Hard	Alk	Ac	NO3&NO2	NO2	NH3-N	Cyanide	Fl
CC1	09-Apr-87	SGC			5.2			680	650	32								
CC1	28-May-87	RN	4.53	3.47	3.7	4.9	140		945		194	nd						
CC1	02-Jul-87	IML	11.47	3.9	4.2	8.8	150	285	110	10	58	0	28	0.62		0.07	nd	0.41
CC1	11-Aug-87	IML	2.44	4.29	4.3	13.2	170	186	140	1	90	4	14	0.18		0.03		0.44
CC1	06-Nov-87	IML	0.49	3.94	4.2	0		409	342	5	188	0	30	0.16		nd	nd	0.95
CC1	13-May-88	IML	9.78	4.4	3.3	5		177	120	13	51	nd	26	0.31		0.04	0.018	0.21
CC1	21-Jul-88	IML	1.65	4.11	4.6	19.5		204	198	3	91	1	14	0.18		0.07	nd	0.35
CC1	31-Aug-88	IML	1.09	5.57	4.7	6		266	186	10	126	1	21	0.18		0.12	nd	0.87
CC1	14-Sep-88	IML	1.87	3.33	3.6	9		351	236	22	143	0	53	0.3		0.1	nd	0.65
CC1	05-Oct-88	IML	0.84	4.62	4.1	6.5		304	208	34	124	nd	28	0.22		0.64	nd	0.67
CC1	26-Apr-89	IML	7.00	4.06	3.6	8	140	260	62	22	93	0	48	0.32		nd	nd	0.84
CC1	31-May-89	IML	15.67	3.86	4.1	12	150	170	468	15	43		11	0.16		<.01	<.005	4.79
CC1	29-Jun-89	IML	5.06	4.59	4.6	7.7	110	169	114	3	66	0	14	0.185		<.1	<.005	0.527
CC1	28-Jul-89	IML	notmeas	4.54	4.4	11	170	213	172	3	95	<.01	13	0.1		<.01	<.005	0.77
CC1	28-Aug-89	IML	0.64	4.24	4.8	10	230	308	210	2	129	2	21	0.24		<.01	<.005	0.75
CC1	25-Sep-89	IML	0.57	4.34	4.4	12.5	250	387	256	6	157	0	1	0.13		0.15	<.005	0.76
CC1	27-Oct-89	IML	notmeas	4.95	4.3	6	260	447	296	13	173	0	18	0.31		<.01	<.005	0.94
CC1	30-Nov-89	IML	notmeas	4.41	4.3	0	390	606	366	4	248	0	30	0.29		<.01	<.005	1.08
CC1.5	12-Mar-90	IML	notmeas	3.83	3.6	7	1000	1060	842	29	518	0	75	0.09		nd	nd	2.66
CC1	07-May-90	IML	3.20	3.54	3.3	2		614	286	54	99	0	128	0.48		0.08	<.005	1.66
CC1	25-Jun-90	IML	8.39	4.32	3.8	13		168	82	56	52	0	15	0.154		0.19	<.005	0.43
CC1	31-Jul-90	IML	0.58	4.32	4.1	11		269	220	8	104	0	25	0.44		0.06	<.005	0.07
CC1	27-Aug-90	IML	notmeas	4.08	4.2	14		349	288	39	120	0	23	<.04		0.03		1.19
CC1	25-Sep-90	IML	notmeas	4.22	3.4	11		338	186	6	124	0	27	0.18		0.13		1.5
CC1	15-Oct-90	IML	3.96	6.14	3.4	8		444	204	20	112	0	65	0.3		0.04	<.005	1.71
CC1	28-Nov-90		no access															
CC1	07-Jan-91		no access															
CC1.5	11-Feb-91	IML	0.23	5.65	3.5	1.9		777	704	4	399	0	75	0.17		<.02		3.05
CC1.5	28-Mar-91	IML	0.32	4.2	4.5	5		839	694	104	425	0	60	0.3		0.12		2.23
CC1.5	17-Apr-91	THE	notmea								458							
CC1.5	23-Apr-91	IML	2.24	3.23	3.1	7.6		789	368	51	399	0	166	0.27		<.04		3.24

TABLE 2
San Juan County Mining Venture-Sunnyside Mine/Mayflower Mill
Water Data Summary METALS
Date Available thru: Site: CC1*
08-Jul-91

Station	Sampldate	dAg	dAl	dAs	dAu	TCd	dCd	TCu	dCu	TCr	dCrT	TFe	dFeIII	TPb	dPb	THg	dHg	TMn	dMn	dSe	dSr	TZn	dZn
		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Mean		0.00	3.07	0.00	0.00	0.007	0.016	0.32	0.38	ERR	0.00	ERR	2.52	0.14	0.06	0.250	0.000	ERR	2.12	0.00	1.18	3.53	3.79
MAX		0.00	12.90	0.03	0.00	0.008	0.070	0.33	1.93	ERR	0.00	ERR	35.70	0.18	0.29	0.300	0.000	ERR	10.38	0.01	1.67	4.80	9.76
MIN		0.00	0.00	0.00	0.00	0.005	0.000	0.30	0.01	ERR	0.00	ERR	0.00	0.10	0.00	0.200	0.000	ERR	0.47	0.00	0.36	2.25	1.09
CC1	09-Apr-87					0.005		0.33						0.1		0.3						4.8	
CC1	28-May-87					0.008		0.3						0.18		0.2						2.25	
CC1	02-Jul-87	nd	0.8	nd			0.032		0.13		nd		0.72		nd		nd		1	0.012			3.8
CC1	11-Aug-87	nd	1.2	nd			0.017		0.22		nd		0.28		nd		nd		0.9	nd			1.94
CC1	06-Nov-87	nd		nd			0.01				nd		0.11		nd		nd		1.36	nd			4.01
CC1	13-May-88	nd	1.7	nd			0.012		0.35		nd		1.98		nd		nd		0.88	nd			2.24
CC1	21-Jul-88	nd	1	nd			0.007		0.19		nd		0.31		nd		nd		0.62	nd			1.79
CC1	31-Aug-88	nd	0.2	nd			0.008		0.27		nd		0.31		nd		nd		1.06	nd			2.6
CC1	14-Sep-88	nd	3.2	nd			0.015		0.56		nd		3.99		0.05		nd		1.81	nd			3.73
CC1	05-Oct-88	nd	5.21	0.005			0.012		0.17		nd		1.71		0.02		nd		1.09	nd			2.84
CC1	26-Apr-89	nd	3.93	nd			0.018		0.67		nd		1.27		0.02		nd		1.11	nd			3.33
CC1	31-May-89	nd	1.8	nd			0.007		0.24		nd		1.24		0.04		nd		0.47	nd			1.35
CC1	29-Jun-89	nd	0.75	nd			nd		0.16		nd		0.27		nd		nd		0.47	nd			1.26
CC1	28-Jul-89	nd	nd	nd			0.007		0.14		nd		0.17		0.02		nd		0.54	nd			1.38
CC1	28-Aug-89	<.01	1.27	nd			0.01		0.16		nd		0.08		0.17		nd		0.73	nd			2.31
CC1	25-Sep-89	nd	1.7	nd			0.005		0.01		nd		0.08		nd		nd		0.79	nd			2.69
CC1	27-Oct-89	nd	2.8	nd			.005		0.2		nd		0.08		nd		nd		0.91	nd			3.11
CC1	30-Nov-89	nd	3.5	nd			0.0062		0.22		nd		nd		nd		nd		1.07	nd			3.51
CC1.5	12-Mar-90	nd	nd	******			0.0333		0.01		nd		0.98		0.257		nd		10.38	nd			7.03
CC1	07-May-90	nd	11.6	0.001			0.0454		1.54		nd		9.3		0.018		nd		3.31	nd			6.86
CC1	25-Jun-90	<.01	1	<.0003			0.0166		0.17		<.02		0.22		<.004		<.0002		0.55	<.0002			1.09
CC1	31-Jul-90	<.01	1.8	<.0003			0.0145		0.26		<.02		0.55		0.018				0.79	<.0002			2.34
CC1	27-Aug-90	<.01	2.3	<.005			<.002		0.3		<.02		0.45		<.005		<.002		1.04	<.005			8.91
CC1	25-Sep-90	<.01	1.6	<.005			0.012		0.27		<.02		0.28		<.005				0.97	<.005			2.94
CC1	15-Oct-90	<.01	4.7	0.002			0.0309		0.68		<.02		3.92		0.032		<.0002		1.51	<.0002			4.19
CC1	28-Nov-90																						
CC1	07-Jan-91																						
CC1.5	11-Feb-91	<.01	6.7	<.0003	<.05		0.0701		0.4		<.02		1.07		0.29		<.0002		8.31	<.0002	1.5		7.43
CC1.5	28-Mar-91	<.01	5.2	<.005	<.05		0.015		0.26		<.02		0.32		0.25		<.001		6.78	<.005	1.67		5.97
CC1.5	17-Apr-91																						
CC1.5	23-Apr-91	<.01	12.9	0.03	<.005		0.008		1.93		<.02		35.7		0.26		<.001		6.61	<.005	0.36		9.76

TABLE 3

San Juan County Mining Venture-Sunnyside Mine/Mayflower Mill

Water Data Summary CAT/AN BAL

Date Available thru: Site: CC1*

08-Jul-91

	Bicarb	CO3	Chloride	Sulfate	Ca	Mg	K	Na
Mean	0	0	2	182	55	6	1	2
MAX	4	0	8	590	168	25	2	8
MIN	0	0	0	50	14	0	0	0

Station	Sampldate	Bicarb (mg/l)	CO3 (mg/l)	Chloride (mg/l)	Sulfate (mg/l)	Ca (mg/l)	Mg (mg/l)	K (mg/l)	Na (mg/l)	% cat/andiff
CC1	09-Apr-87									
CC1	28-May-87			nd	80.0	76.4	0.9	nd	3.0	
CC1	02-Jul-87	0.0	0.0	0.0	60.0	16.0	4.0	nd	1.0	18.0
CC1	11-Aug-87	4.0	0.0	1.0	96.0	28.0	5.0	nd	1.0	0.7
CC1	06-Nov-87	0.0	0.0	0.0	210.0	64.0	6.0	nd	2.0	0.4
CC1	13-May-88	nd	nd	nd	60.0	14.0	4.0	nd	nd	8.6
CC1	21-Jul-88	1.0	0.0	1.0	100.0	31.0	3.0	1.0	1.0	3.2
CC1	31-Aug-88	1.0	0.0	2.0	120.0	35.0	10.0	1.0	1.0	6.4
CC1	14-Sep-88	0.0	0.0	1.0	140.0	37.0	12.0	nd	2.0	15.4
CC1	05-Oct-88	0.0	0.0	2.0	140.0	42.0	5.0	1.0	1.0	2.5
CC1	26-Apr-89	0.0	0.0	3.0	86.0	23.0	1.0	1.0	4.0	8.0
CC1	31-May-89			<.01	50.2	16.8	0.2	0.9	8.4	1.4
CC1	29-Jun-89	0.0	0.0	1.0	65.0	22.0	3.0	2.0	2.0	2.1
CC1	28-Jul-89	<.01	<.01	1.1	90.9	36.5	1.1	1.2	1.0	7.3
CC1	28-Aug-89	2.3	<.1	1.1	138.3	46.8	3.0	0.8	1.5	2.1
CC1	25-Sep-89	0.0	0.0	<.01	156.6	21.1	24.6	0.7	2.1	0.8
CC1	27-Oct-89	0.0	0.0	0.0	184.8	64.0	3.1	0.6	2.2	0.1
CC1	30-Nov-89	0.0	0.0	0.0	275.7	94.3	3.2	0.5	5.1	0.4
CC1.5	12-Mar-90	0.0	0.0	5.4	542.4	168.4	23.7	0.6	4.9	2.7
CC1	07-May-90	0.0	0.0	0.5	217.3	38.6	0.8	1.4	1.1	0.7
CC1	25-Jun-90	0.0	0.0	4.2	57.6	17.7	2.0	0.8	0.4	2.0
CC1	31-Jul-90	0.0	0.0	2.1	125.5	36.9	3.0	1.4	1.6	0.2
CC1	27-Aug-90	0.0	0.0	2.1	135.0	43.4	3.0	0.9	1.5	1.6
CC1	25-Sep-90	0.0	0.0	4.2	140.0	48.2	1.0	0.6	1.9	1.2
CC1	15-Oct-90	0.0	0.0	8.2	160.0	20.9	14.7	0.6	3.5	1.6
CC1	28-Nov-90									
CC1	07-Jan-91									
CC1.5	11-Feb-91	0.0	0.0	2.0	439.0	135.0	15.2	0.7	4.1	2.5
CC1.5	28-Mar-91	0.0	0.0	3.1	462.0	147.0	14.1	0.6	2.3	0.6
CC1.5	17-Apr-91									
CC1.5	23-Apr-91	0.0	0.0	1.5	590.0	158.0	1.2	0.6	1.8	4.0

TABLE 4
San Juan County Mining Venture-Sunnyside Mine/Mayflower Mill
Water Data Summary   BIOMONITORING DATA
Date Available thru: Site: CC1*
08-Jul-91

Mean			0		0	308	ERR	ERR	ERR	653	ERR	950	0.20	ERR				
MAX			0		0	308	ERR	ERR	ERR	653	ERR	950	0.20	ERR				
MIN			0		0	308	ERR	ERR	ERR	653	ERR	950	0.20	ERR				
----------------		LC50	%SURV	LC50	%SURV	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	----------	----------	----------	----------
Station	Sampldate	FHM	FHM100%	Cerio	Cerio100%	ReconHard	ReconCond	ReconAlk	RcvHard	EFFHard	EFFAlk	EFFCon	EFFAmm	EFFCl	Date strt	Time strt	pH strt	pHend
CC1	09-Apr-87																	
CC1	28-May-87																	
CC1	02-Jul-87																	
CC1	11-Aug-87																	
CC1	06-Nov-87																	
CC1	13-May-88																	
CC1	21-Jul-88																	
CC1	31-Aug-88																	
CC1	14-Sep-88																	
CC1	05-Oct-88																	
CC1	26-Apr-89																	
CC1	31-May-89																	
CC1	29-Jun-89																	
CC1	28-Jul-89																	
CC1	28-Aug-89																	
CC1	25-Sep-89																	
CC1	27-Oct-89																	
CC1	30-Nov-89																	
CC1.5	12-Mar-90	33	0	1	0	308				653		950	0.2					
CC1	07-May-90																	
CC1	25-Jun-90																	
CC1	31-Jul-90																	
CC1	27-Aug-90																	
CC1	25-Sep-90																	
CC1	15-Oct-90																	
CC1	28-Nov-90																	
CC1	07-Jan-91																	
CC1.5	11-Feb-91																	
CC1.5	28-Mar-91																	
CC1.5	17-Apr-91																	
CC1.5	23-Apr-91																	

Eureka Creek

TABLE 1
San Juan County Mining Venture-Sunnyside Mine/Mayflower Mill
Water Data Summary Site: EC1
Date Available thru:
09-Jul-91

Station	Sampldate	lab	Qmgd	FieldpH	labpH	FieldT	FieldCond	labcond	TDS(180)	TSS	Hard	Alk	Ac	NO3&NO2	NO2	NH3-N	Cyanide	Fl
Mean				7.4	7.1	7.6	132	239	127	41	89	19	0	0.93	ERR	0.17	0.02	0.31
MAX				8.0	8.6	18.0	170	742	182	154	122	25	0	10.50	ERR	0.51	0.22	0.87
MIN				7.0	6.1	1.0	86	149	50	1	62	13	0	0.00	ERR	0.00	0.00	0.00
						C	uS	uS	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
EC1	22-Oct-87	IML	0.05	7.3	8.6	7		742	134	28								
EC1	22-Jul-88	IML	0.68	7.0	7.1	8		150	140	4	71	21	nd	0.06		0.06	nd	0.18
EC1	31-Aug-88	IML	0.30	7.5	6.7	8.5		195	124	45	100	21	nd	0.38		0.26		0.49
EC1	26-Sep-88	IML	0.53	7.0	6.5	7		203	136	146	98	21	nd	0.15		0.06	nd	0.07
EC1	12-Oct-88	IML	0.43	7.0	6.1	2		207	154	154	93	19	nd	10.5		0.27	nd	0.14
EC1	25-May-89	IML	notmeas	7.2	6.4	1		149	92	13	62	14	<.1	0.2		0.506	0.215	0.233
EC1	07-Jun-89	IML	5.20	7.6	6.8	6.5	90	159	50	6	66	14	<1	0.242		<.01	<.005	0.372
EC1	13-Jul-89	IML	1.78	7.8	7	8.5	86	159	106	6	68	21	<.01	0.143		<.1	<.005	na
EC1	29-Aug-89	IML	0.18	7.2	7.25	10	170	226	144	1	101	25	<.01	0.24		<.1	<.005	0.21
EC1	26-Sep-89	IML	0.07	7.8	7.08	8.5	145	287	182	10	122	23	0	0.14		0.13	<.005	0.23
EC1	26-Oct-89	IML	0.07	7.4	7.32	1.5	170	270	166	148	109	13	0	0.31		<.01	<.005	0.34
EC1	27-Jun-90	IML	3.80	8.0	7.57	10		174	94	2	68	15	0	<.04		0.34	<.005	0.41
EC1	30-Jul-90	IML	0.34	7.2	7.9	10		188	146	5	92	19	0	0.31		0.06		0.54
EC1	30-Aug-90	IML	0.30	7.6		18								0.17		0.38		
EC1	25-Sep-90	IML	0.26	7.4	7.18	8		236	106	4	110	17	0	0.24		0.34		0.87

EC1 Table 1

TABLE 2
San Juan County Mining Venture-Sunnyside Mine/Mayflower Mill
Water Data Summary METALS
Date Available thru: Site: EC1
09-Jul-91

		dAg	dAl	dAs	dAu	TCd	dCd	TCu	dCu	TCr	dCrT	TFe	dFeIII	TPb	dPb	THg	dHg	TMn	dMn	dSe	dSr	TZn	dZn
Mean		0.00	1.02	0.01	ERR	0.003	0.001	0.10	0.03	ERR	0.00	ERR	0.72	0.17	0.08	0.000	0.000	ERR	0.88	0.00	ERR	0.95	0.56
MAX		0.01	14.10	0.12	ERR	0.003	0.006	0.10	0.16	ERR	0.00	ERR	7.72	0.17	0.75	0.000	0.001	ERR	3.47	0.00	ERR	0.95	0.99
MIN		0.00	0.00	0.00	ERR	0.003	0.000	0.10	0.00	ERR	0.00	ERR	0.00	0.17	0.00	0.000	0.000	ERR	0.14	0.00	ERR	0.95	0.24
-----------------		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Station	Sampldate	dAg	dAl	dAs	dAu	TCd	dCd	TCu	dCu	TCr	dCrT	TFe	dFeIII	TPb	dPb	THg	dHg	TMn	dMn	dSe	dSr	TZn	dZn
EC1	22-Oct-87					0.003		0.1						0.17		nd						0.95	
EC1	22-Jul-88	nd	nd	nd			T		nd		nd		nd		nd		nd		0.2	nd			0.24
EC1	31-Aug-88	nd	0.1	nd			T		0.01		nd		0.24		0.03		nd		0.89	nd			0.51
EC1	26-Sep-88	nd	nd	nd			0.002		0.08		nd		1.17		0.29		nd		1.06	nd			0.49
EC1	12-Oct-88	nd	14.1	0.005			0.006		0.16		nd		7.72		0.75		nd		3.47	nd			0.99
EC1	25-May-89	<.01	nd	<.005			0.004		0.01		nd		nd		<.02		0.001		0.87	<.005			0.78
EC1	07-Jun-89	<.01	nd	<.005			<.002		0.01		nd		nd		<.02		<.001		1.02	<.005			0.85
EC1	13-Jul-89	0.01	nd	<.005			<.002		0.02		nd		0.05		<.02		na		0.15	na			0.25
EC1	29-Aug-89	<.01	nd	<.005			<.002		0.02		nd		nd		0.08		<.001		0.43	<.005			0.39
EC1	26-Sep-89	nd	nd	0.12			nd				nd				nd		nd		0.89	nd			0.6
EC1	26-Oct-89	nd	nd	nd			0.003		0.02		nd		0.05		nd				0.14	nd			0.24
EC1	27-Jun-90	<.01	0.1	0.0012			0.0037		0.02		<.02		<.05		0.005		<.0002		0.9	<.0002			0.7
EC1	30-Jul-90	<.01	<.1	<.0003			0.0015		0.03		<.02		<.05		0.009		<.0002		0.53	<.0002			0.44
EC1	30-Aug-90	<.01	<.1	<.005			<.002		0.01		<.02		0.05		<.005		<.002		0.86	<.005			0.61
EC1	25-Sep-90	<.01	<.1	<.005			<.002		0.01		<.02		0.05		<.005		<.002		0.87	<.005			0.7

EC1 Table 2

TABLE 3
San Juan County Mining Venture-Sunnyside Mine/Mayflower Mill
Water Data Summary CAT/AN BAL
Date Available thru: Site: EC1
09-Jul-91

Mean		23	0	2	68	28	4	1	1	
MAX		30	0	4	98	36	17	1	2	
MIN		16	0	0	49	21	0	0	0	
		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	%
Station	Sampldate	Bicarb	CO3	Chloride	Sulfate	Ca	Mg	K	Na	cat/andiff
EC1	22-Oct-87									
EC1	22-Jul-88	25.0	0.0	nd	50.0	28.0	nd	nd	1.0	1.7
EC1	31-Aug-88	26.0	0.0	4.0	70.0	31.0	5.0	1.0	1.0	3.0
EC1	26-Sep-88	25.0	0.0	1.0	70.0	33.0	4.0	1.0	nd	0.3
EC1	12-Oct-88	23.0	0.0	1.0	70.0	33.0	3.0	nd	nd	0.5
EC1	25-May-89	16.5	0.0	<.01	48.8	20.7	2.4	0.5	1.4	0.4
EC1	07-Jun-89	16.5	<1	2.8	51.2	22.1	2.7	0.4	1.8	0.4
EC1	13-Jul-89	25.0	<.01	1.8	48.6	25.4	1.0	0.5	0.7	2.8
EC1	29-Aug-89	30.1	<.1	1.1	78.6	34.7	3.5	0.7	1.2	1.8
EC1	26-Sep-89	27.8	0.0	<.1	97.5	21.1	16.9	0.6	1.3	0.5
EC1	26-Oct-89	15.7	0.0	0.0	89.1	33.7	6.2	0.5	1.0	1.6
EC1	27-Jun-90	18.6	0.0	2.1	51.4	22.5	3.0	0.8	0.4	1.2
EC1	30-Jul-90	23.3	0.0	4.2	66.3	28.9	4.9	1.3	1.1	0.7
EC1	30-Aug-90									
EC1	25-Sep-90	20.7	0.0	2.1	88.1	36.1	4.9	0.4	1.0	0.2

EC1 Table 3

American Tunnel Seep

TABLE 1
San Juan County Mining Venture-Sunnyside Mine/Mayflower Mill
Water Data Summary Site: ATS1*
Date Available thru:
09-Jul-91

Station	Sampldate	lab	Qmgd	FieldpH	labpH	FieldT	FieldCond	labcond	TDS(180)	TSS	Hard	Alk	Ac	NO3&NO2	NO2	NH3-N	Cyanide	Fl
Mean				5.0	4.6	11.2	420	669	516	34	355	0	87	0.93	ERR	0.10	0.00	2.81
MAX				5.8	5.5	17.0	420	875	820	95	587	0	236	2.64	ERR	0.17	0.00	6.56
MIN				4.7	3.2	6.0	420	449	303	5	209	0	24	0.00	ERR	0.00	0.00	1.27
						C	uS	uS	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
ATS1	01-Sep-86		0.001	5.78					303	5				nd				
ATS1	28-Oct-88		0.000															
ATS1	11-May-89	IML	0.007	4.76	4.60	9		875	820	31	587	0	236	1.91		0.17	nd	6.56
ATS1	22-Jun-89	IML	0.000															
ATS1	05-Oct-89	IML	0.007	5.20	4.94	6	420	647	482	6	312	0	24	2.64		<.01	<.005	1.68
ATS1	13-Jun-90	IML	0.003	4.73	5.51	10		449	410	95	209	0	28	<.04		0.13	<.005	1.27
ATS1	10-Jul-90	IML	0.001	5.05	3.22	17		704	564		311	0	60	0.09			<.005	1.73
ATS1	07-Aug-90	IML	0.000															
ATS1	11-Sep-90	IML	0.000															
ATS1	23-Oct-90	IML	0.000															
ATS1	14-May-91		0.000															
ATS1	13-Jun-91		0.014	4.76		14												

ATS1 Table 1

TABLE 2
San Juan County Mining Venture-Sunnyside Mine/Mayflower Mill
Water Data Summary METALS
Date Available thru: Site: ATS1*
09-Jul-91

		dAg	dAl	dAs	dAu	TCd	dCd	TCu	dCu	TCr	dCrT	TFe	dFeIII	TPb	dPb	THg	dHg	TMn	dMn	dSe	dSr	TZn	dZn
Mean		0.01	2.45	0.00	ERR	ERR	0.079	ERR	0.26	ERR	0.00	ERR	0.34	ERR	0.17	ERR	0.006	ERR	17.17	0.00	ERR	ERR	12.94
MAX		0.02	5.90	0.00	ERR	ERR	0.341	ERR	1.07	ERR	0.00	ERR	0.75	ERR	0.69	ERR	0.031	ERR	65.70	0.00	ERR	ERR	51.20
MIN		0.00	0.90	0.00	ERR	ERR	0.002	ERR	0.02	ERR	0.00	ERR	0.09	ERR	0.01	ERR	0.000	ERR	1.24	0.00	ERR	ERR	1.81
-----------------		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Station	Sampldate	dAg	dAl	dAs	dAu	TCd	dCd	TCu	dCu	TCr	dCrT	TFe	dFeIII	TPb	dPb	THg	dHg	TMn	dMn	dSe	dSr	TZn	dZn
ATS1	01-Sep-86						0.002		0.02				0.40		0.03		0.031		4.50				1.89
ATS1	28-Oct-88																						
ATS1	11-May-89	0.02	5.90	nd			0.341		1.07		<.02		0.09		0.69		nd		65.70	nd			51.20
ATS1	22-Jun-89																						
ATS1	05-Oct-89	nd	1.60	nd			0.034		0.11		nd		0.12		0.09		nd		4.44	nd			4.81
ATS1	13-Jun-90	<.01	0.90	0.002			0.002		0.03		<.02		0.32		0.03		<.0002		1.24	<0002			1.81
ATS1	10-Jul-90	<.01	1.40	0.001			0.014		0.06		<.02		0.75		0.01		<.0002		9.95	<.0002			4.98
ATS1	07-Aug-90																						
ATS1	11-Sep-90																						
ATS1	23-Oct-90																						
ATS1	14-May-91																						
ATS1	13-Jun-91																						

ATS1 Table 2

ounty Mining Venture-Sunnyside Mine/Mayflower Mill

Data Summary CAT/AN BAL

ce Available thru: Site: ATS1*

09-Jul-91

Station	Sampldate	Bicarb	CO3	Chloride	Sulfate	Ca	Mg	K	Na	cat/andiff
Mean		0	0	1	262	99	26	2	5	
MAX		0	0	2	403	122	69	3	6	
MIN		0	0	0	19	72	7	1	2	
		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	%
ATS1	01-Sep-86				19					
ATS1	28-Oct-88									
ATS1	11-May-89	0	0	0	403	122	69	3	2	4
ATS1	22-Jun-89									
ATS1	05-Oct-89	0	0	<.01	317	101	14	2	6	0
ATS1	13-Jun-90	0	0	2	229	72	7	1	4	1
ATS1	10-Jul-90	0	0	2	344	100	15	2	6	3
ATS1	07-Aug-90									
ATS1	11-Sep-90									
ATS1	23-Oct-90									
ATS1	14-May-91									
ATS1	13-Jun-91									

ATS1 Table

APPENDIX D

Laboratory Data Sheets for Waters Entering the American Tunnel Level of the Sunnyside Mine

ROOT & NORTON LABORATORIES
SILVERTON, COLORADO 81433

P.O. BOX 309
303-387-5492

CERTIFICATE OF WATER ANALYSIS

CLIENT: SJCMV - Sunnyside Mine
REPORT DATE: 3/8/91
SAMPLE ID: 0700 RA
LAB ID: AT1397
SAMPLE DATE: 3/5/91 TIME: 11:10
SAMPLED BY: EB DATE REC'D: 3/5 ANALYZED: 3/6

PARAMETERS	SAMPLE VALUE		% RSD		SPIKE RECOVERY	CONTROL RECOVERY	
TEMPERATURE		C.					
pH	7.76	s.u.					
T. SUSPENDED SLDS	117.1	mg/L					
T. DISSOLVED SLDS		mg/L					
CONDUCTIVITY .... (/cm @ 25 C)		umhos					
T. HARDNESS .... (as CaCO3-EDTA)		mg/L					
T. LEAD	8.46	mg/L	1.7	%	%	98	%
T. COPPER	0.51	mg/L	2.7	%	%	101	%
T. ZINC	9.16	mg/L	1.2	%	%	92	%
T. CADMIUM	0.052	mg/L	18.6	%	%	104	%
T. CHROMIUM		mg/L		%	%		%
T. MANGANESE.....	1.44	mg/L	1.6	%	%	103	%
T. IRON	5.40	mg/L	1.1	%	%	90	%
T. CYANIDE		mg/L		%	%		%
T. MERCURY		mg/L		%	%		%

Metals Digestion: Total Recoverable

Remarks:

CERTIFIED BY: ______________________ Charges $ 49.00

ROOT & NORTON LABORATORIES
SILVERTON, COLORADO 81433

P.O. BOX 309
303-387-5492

CERTIFICATE OF WATER ANALYSIS

CLIENT: SJCMV - Sunnyside Mine
SAMPLE ID: 21950 P
SAMPLE DATE: 3/5/91 TIME: 9:10 am
SAMPLED BY: EB DATE REC'D: 3/5 ANALYZED: 3/6

REPORT DATE: 3/8/91
LAB ID: AT1400

PARAMETERS	SAMPLE VALUE		% RSD		SPIKE RECOVERY	CONTROL RECOVERY	
TEMPERATURE		C.					
pH	2.35	s.u.					
T. SUSPENDED SLDS	65.6	mg/L					
T. DISSOLVED SLDS		mg/L					
CONDUCTIVITY .... (/cm @ 25 C)		umhos					
T. HARDNESS .... (as CaCO3-EDTA)		mg/L					
T. LEAD	2.58	mg/L	3.0	%	%	92	%
T. COPPER	25.1	mg/L	4.1	%	%	104	%
T. ZINC	566.9	mg/L	0.0	%	%	100	%
T. CADMIUM	1.50	mg/L	2.5	%	%	88	%
T. CHROMIUM		mg/L		%	%		%
T. MANGANESE.....	840.4	mg/L	0.1	%	%	96	%
T. IRON	203.0	mg/L	2.1	%	%	100	%
T. CYANIDE		mg/L		%	%		%
T. MERCURY		mg/L		%	%		%

Metals Digestion: Total Recoverable

Remarks:

CERTIFIED BY: ______________________ Charges $ 49.00

Inter-Mountain Laboratories, Inc.

2506 West Main Street
Farmington, New Mexico 87401
Tel. (505) 326-4737

CLIENT:	Sunnyside Gold	DATE REPORTED:	03/27/91
ID:	0910		
SITE:	2195 OP	DATE RECEIVED:	03/07/91
LAB NO:	F5884	DATE COLLECTED:	03/05/91

Lab pH (s.u.)	2.86
Lab conductivity, umhos/cm	63200
Lab resistivity, ohm-m	0.158
Total dissolved solids (180), mg/l	9130
Total dissolved solids (calc), mg/l	7710
Total suspended solids, mg/l	8
Total alkalinity as CaCO3, mg/l	0
Total acidity as CaCO3, mg/l	2730
Total hardness as CaCO3, mg/l	5810
Sodium absorption ratio	0.056
Total ortho-phosphate, mg/l	1.23
Fluoride, mg/l	2.47
Total nitrate and nitrite, mg/l	47.9
Ammonia, mg/l	18.56

	mg/l	meq/l
Bicarbonate as HCO3	0	0
Carbonate as CO3	0	0
Chloride	9.19	0.26
Sulfate	5550	116
Calcium	1860	92.8
Magnesium	285	23.4
Potassium	2.09	0.05
Sodium	9.8	0.43
Major cations		171
Major anions		119
Cation/anion difference		17.9 %

**Sample rerun, no significant changes.

Inter-Mountain Laboratories, Inc.

2506 West Main Street
Farmington, New Mexico 87401
Tel. (505) 326-4737

CLIENT:	Sunnyside Gold	DATE REPORTED:	03/28/91
ID:	0910		
SITE:	2195 OP	DATE RECEIVED:	03/07/91
LAB NO:	F5884	DATE COLLECTED:	03/05/91

Trace metals by AA (dissolved concentration), mg/l

	Analytical Result:	Detection Limit:
Arsenic (As)................	0.036	<0.0003
Cadmium (Cd)................	2.065	<0.0002
Mercury (Hg)................	ND	<0.001
Lead (Pb)...................	1.525	<0.004
Selenium (Se)...............	ND	<0.005

Trace metals by ICAP (dissolved concentration), mg/l

	Analytical Result:	Detection Limit:
Silver (Ag).................	ND	<0.01
Aluminum (Al)...............	101	<0.1
Gold (Au)...................	ND	<0.05
Boron (B)...................	ND	<0.01
Chromium (Cr)...............	ND	<0.02
Copper (Cu).................	24.8	<0.01
Iron (Fe)...................	192	<0.05
Manganese (Mn)..............	946	<0.02
Strontium (Sr)..............	3.62	<0.05
Zinc (Zn)...................	701	<0.01

ND - Analyte "not detected" at the stated detection limit.

Mary Stepp

Mary Stepp
Lab Director

Inter-Mountain Laboratories, Inc.

2506 West Main Street
Farmington, New Mexico 87401
Tel. (505) 326-4737

CLIENT:	Sunnyside Gold	DATE REPORTED:	03/27/91
ID:	1110		
SITE:	0700 RA	DATE RECEIVED:	03/07/91
LAB NO:	F5865	DATE COLLECTED:	03/05/91

Trace metals by AA (dissolved concentration), mg/l

	Analytical Result:	Detection Limit:
Arsenic (As)................	ND	<0.005
Cadmium (Cd)................	ND	<0.002
Mercury (Hg)................	ND	<0.001
Lead (Pb)...................	0.019	<0.004
Selenium (Se)...............	ND	<0.006

Trace metals by ICAP (dissolved concentration), mg/l

	Analytical Result:	Detection Limit:
Silver (Ag).................	ND	<0.01
Aluminum (Al)...............	0.1	<0.1
Gold (Au)...................	ND	<0.05
Boron (B)...................	0.04	<0.01
Chromium (Cr)...............	ND	<0.02
Copper (Cu).................	ND	<0.01
Iron (Fe)...................	0.31	<0.05
Manganese (Mn)..............	1.37	<0.02
Strontium (Sr)..............	6.41	<0.05
Zinc (Zn)...................	0.92	<0.01

ND - Analyte "not detected" at the stated detection limit.

Mary Stepp

Mary Stepp
Lab Director

ROOT & NORTON LABORATORIES
SILVERTON, COLORADO 81433

P.O. BOX 309
303-387-5492

CERTIFICATE OF WATER ANALYSIS

CLIENT: SJCMV - Sunnyside Mine
REPORT DATE: 3/8/91
SAMPLE ID: SS Drift
LAB ID: AT1396
SAMPLE DATE: 3/5/91 TIME: 10:30
SAMPLED BY: EB DATE REC'D: 3/5 ANALYZED: 3/6

PARAMETERS	SAMPLE VALUE		% RSD		SPIKE RECOVERY		CONTROL RECOVERY	
TEMPERATURE		C.						
pH	7.57	s.u.						
T. SUSPENDED SLDS	0.04	mg/L						
T. DISSOLVED SLDS		mg/L						
CONDUCTIVITY .... (/cm @ 25 C)		umhos						
T. HARDNESS .... (as CaCO3-EDTA)		mg/L						
T. LEAD	0.18	mg/L	3.8	%	106	%	108	%
T. COPPER	0.02	mg/L	30.1	%	97	%	101	%
T. ZINC	0.09	mg/L	17.1	%	92	%	100	%
T. CADMIUM	0.000	mg/L		%	112	%	104	%
T. CHROMIUM		mg/L		%		%		%
T. MANGANESE.....	1.83	mg/L	2.0	%	98	%	103	%
T. IRON	0.25	mg/L	10.0	%	100	%	110	%
T. CYANIDE		mg/L		%		%		%
T. MERCURY		mg/L		%		%		%

Metals Digestion: Total Recoverable

Remarks:

CERTIFIED BY: ____________________ Charges $ 49.00

Inter-Mountain Laboratories, Inc.

2506 West Main Street
Farmington, New Mexico 87401
Tel. (505) 326-4737

CLIENT:	Sunnyside Gold	DATE REPORTED:	03/27/91
ID:	1030		
SITE:	SS Drift	DATE RECEIVED:	03/07/91
LAB NO:	F5883	DATE COLLECTED:	03/05/91

Lab pH (s.u.)	7.60
Lab conductivity, umhos/cm	1340
Lab resistivity, ohm-m	7.46
Total dissolved solids (180), mg/l	1280
Total dissolved solids (calc), mg/l	1140
Total suspended solids, mg/l	1
Total alkalinity as CaCO3, mg/l	82.1
Total hardness as CaCO3, mg/l	833
Sodium absorption ratio	0.194
Total ortho-phosphate, mg/l	<0.02
Fluoride, mg/l	2.39
Total nitrate and nitrite, mg/l	0.17
Ammonia, mg/l	<0.02

	mg/l	meq/l
Bicarbonate as HCO3	100	1.64
Carbonate as CO3	0	0
Chloride	3.06	0.09
Sulfate	769	16
Calcium	267	13.3
Magnesium	40.4	3.32
Potassium	1.13	0.03
Sodium	12.9	0.56
Major cations		17.2
Major anions		17.8
Cation/anion difference		1.65 %

iml
Inter·Mountain
Laboratories, Inc.

2506 West Main Street
Farmington, New Mexico 87401
Tel. (505) 326-4737

CLIENT:	Sunnyside Gold	DATE REPORTED:	03/27/91
ID:	1030		
SITE:	SS Drift	DATE RECEIVED:	03/07/91
LAB NO:	F5883	DATE COLLECTED:	03/05/91

Trace metals by AA (dissolved concentration), mg/l

	Analytical Result:	Detection Limit:
Arsenic (As)................	ND	<0.005
Cadmium (Cd)................	0.003	<0.0002
Mercury (Hg)................	ND	<0.001
Lead (Pb)................	ND	<0.005
Selenium (Se)................	ND	<0.005

Trace metals by ICAP (dissolved concentration), mg/l

	Analytical Result:	Detection Limit:
Silver (Ag)................	ND	<0.01
Aluminum (Al)................	ND	<0.1
Gold (Au)................	ND	<0.05
Boron (B)................	0.06	<0.01
Chromium (Cr)................	ND	<0.02
Copper (Cu)................	ND	<0.01
Iron (Fe)................	0.14	<0.05
Manganese (Mn)................	2.10	<0.02
Strontium (Sr)................	6.03	<0.05
Zinc (Zn)................	0.09	<0.01

ND - Analyte "not detected" at the stated detection limit.

Mary Stepp
Mary Stepp
Lab Director

Inter·Mountain Laboratories, Inc.

2506 West Main Street
Farmington, New Mexico 87401
Tel. (505) 326-4737

CLIENT:	Sunnyside Gold	DATE REPORTED:	04/11/91
ID:	1250		
SITE:	SS Drift	DATE RECEIVED:	03/18/91
LAB NO:	F5910	DATE COLLECTED:	03/13/91

Lab pH (s.u.)	7.18
Lab conductivity, umhos/cm	1430
Lab resistivity, ohm-m	7.02
Total dissolved solids (180), mg/l	1250
Total dissolved solids (calc), mg/l	1130
Total suspended solids, mg/l	1
Total alkalinity as CaC03, mg/l	94
Total hardness as CaC03, mg/l	843
Sodium absorption ratio	0.178
Total ortho-phosphate, mg/l	<0.02
Fluoride, mg/l	1.79
Total nitrate and nitrite, mg/l	0.12
Ammonia, mg/l	<0.02

	mg/l	meq/l
Bicarbonate as HC03	98.2	1.61
Carbonate as C03	0	0
Chloride	1.02	0.03
Sulfate	766	16
Calcium	252	12.6
Magnesium	52.1	4.29
Potassium	1.05	0.03
Sodium	11.9	0.52
Major cations		17.4
Major anions		17.6
Cation/anion difference		0.61 %

Inter·Mountain Laboratories, Inc.

2506 West Main Street
Farmington, New Mexico 87401
Tel. (505) 326-4737

CLIENT:	Sunnyside Gold	DATE REPORTED:	04/11/91
ID:	1250		
SITE:	SS Drift	DATE RECEIVED:	03/18/91
LAB NO:	F5910	DATE COLLECTED:	03/13/91

Trace metals by AA (dissolved concentration), mg/l

	Analytical Result:	Detection Limit:
Arsenic (As)................	ND	<0.005
Cadmium (Cd)................	ND	<0.002
Mercury (Hg)................	ND	<0.001
Lead (Pb)..................	ND	<0.005
Selenium (Se)...............	ND	<0.005

Trace metals by ICAP (dissolved concentration), mg/l

	Analytical Result:	Detection Limit:
Silver (Ag)................	ND	<0.01
Aluminum (Al)..............	ND	<0.1
Gold (Au)..................	ND	<0.05
Boron (B)..................	0.03	<0.01
Chromium (Cr)..............	ND	<0.02
Copper (Cu)................	ND	<0.01
Iron (Fe)..................	ND	<0.05
Manganese (Mn).............	1.87	<0.02
Strontium (Sr).............	5.78	<0.05
Zinc (Zn)..................	0.06	<0.01

ND - Analyte "not detected" at the stated detection limit.

Mary Stepp

Mary Stepp
Lab Director

ROOT & NORTON LABORATORIES
SILVERTON, COLORADO 81433

P.O. BOX 309
303-387-5492

CERTIFICATE OF WATER ANALYSIS

CLIENT: SJCMV - Sunnyside Mine
REPORT DATE: 3/18/91
SAMPLE ID: SS Drift
LAB ID: AT1418
SAMPLE DATE: 3/13/91 TIME: 12:50
SAMPLED BY: EB DATE REC'D: 3/13 ANALYZED: 3/14

PARAMETERS	SAMPLE VALUE		% RSD		SPIKE RECOVERY		CONTROL RECOVERY	
TEMPERATURE		C.						
pH	7.60	s.u.						
T. SUSPENDED SLDS	0.00	mg/L						
T. DISSOLVED SLDS		mg/L						
CONDUCTIVITY .... (/cm @ 25 C)		umhos						
T. HARDNESS .... (as CaCO3-EDTA)		mg/L						
T. LEAD	0.08	mg/L	12.0	%	91	%	106	%
T. COPPER	< 0.01	mg/L	na	%	96	%	93	%
T. ZINC	0.07	mg/L	3.4	%	90	%	94	%
T. CADMIUM	0.004	mg/L	40.0	%	78	%	92	%
T. CHROMIUM		mg/L		%		%		%
T. MANGANESE.....	1.94	mg/L	0.6	%	98	%	97	%
T. IRON	0.18	mg/L	3.9	%	87	%	90	%
T. CYANIDE		mg/L		%		%		%
T. MERCURY		mg/L		%		%		%

Metals Digestion: Total Recoverable

Remarks:

CERTIFIED BY: [signature] Charges $ 49.00

ROOT & NORTON LABORATORIES
SILVERTON, COLORADO 81433

P.O. BOX 309
303-387-5492

CERTIFICATE OF WATER ANALYSIS

CLIENT: SJCMV - Sunnyside Mine
REPORT DATE: 3/8/91
SAMPLE ID: W.SH HW
LAB ID: AT14.3
SAMPLE DATE: 3/5/91 TIME: 7:55 am
SAMPLED BY: EB DATE REC'D: 3/5 ANALYZED: 3/6

PARAMETERS	SAMPLE VALUE		% RSD		SPIKE RECOVERY	CONTROL RECOVERY	
TEMPERATURE		C.					
pH	7.18	s.u.					
T. SUSPENDED SLDS	1.22	mg/L					
T. DISSOLVED SLDS		mg/L					
CONDUCTIVITY .... (/cm @ 25 C)		umhos					
T. HARDNESS .... (as CaCO3-EDTA)		mg/L					
T. LEAD	0.19	mg/L	9.4	%	%	92	%
T. COPPER	0.03	mg/L	9.7	%	%	101	%
T. ZINC	0.59	mg/L	3.6	%	%	92	%
T. CADMIUM	0.005	mg/L	20.8	%	%	104	%
T. CHROMIUM		mg/L		%	%		%
T. MANGANESE.....	1.58	mg/L	2.2	%	%	103	%
T. IRON	0.17	mg/L	11.3	%	%	95	%
T. CYANIDE		mg/L		%	%		%
T. MERCURY		mg/L		%	%		%

Metals Digestion: Total Recoverable

Remarks:

CERTIFIED BY: ____________________ Charges $ 49.00

Inter-Mountain Laboratories, Inc.

2506 West Main Street
Farmington, New Mexico 87401
Tel. (505) 326-4737

CLIENT:	Sunnyside Gold	DATE REPORTED:	03/28/91
ID:	0755		
SITE:	Wash HW	DATE RECEIVED:	03/07/91
LAB NO:	F5881	DATE COLLECTED:	03/05/91

Lab pH (s.u.)	7.54
Lab conductivity, umhos/cm	1860
Lab resistivity, ohm-m	5.37
Total dissolved solids (180), mg/l	1970
Total dissolved solids (calc), mg/l	1710
Total suspended solids, mg/l	<1.0
Total alkalinity as CaCO3, mg/l	65
Total hardness as CaCO3, mg/l	1270
Sodium absorption ratio	0.181
Total ortho-phosphate, mg/l	<0.02
Fluoride, mg/l	2.47
Total nitrate and nitrite, mg/l	<0.04
Ammonia, mg/l	<0.02

	mg/l	meq/l
Bicarbonate as HCO3	79.3	1.3
Carbonate as CO3	0	0
Chloride	4.08	0.12
Sulfate	1220	25.4
Calcium	310	15.5
Magnesium	121	9.91
Potassium	1.17	0.03
Sodium	14.8	0.64
Major cations		26
Major anions		26.9
Cation/anion difference		1.54 %

iml
Inter-Mountain
Laboratories, Inc.

2506 West Main Street
Farmington, New Mexico 87401
Tel. (505) 326-4737

CLIENT:	Sunnyside Gold	DATE REPORTED:	03/27/91
ID:	0755		
SITE:	Wash HW	DATE RECEIVED:	03/07/91
LAB NO:	F5881	DATE COLLECTED:	03/05/91

Trace metals by AA (dissolved concentration), mg/l

	Analytical Result:	Detection Limit:
Arsenic (As)................	ND	<0.005
Cadmium (Cd)................	0.005	<0.0002
Mercury (Hg)................	ND	<0.001
Lead (Pb)..................	ND	<0.005
Selenium (Se)...............	ND	<0.005

Trace metals by ICAP (dissolved concentration), mg/l

	Analytical Result:	Detection Limit:
Silver (Ag)................	ND	<0.01
Aluminum (Al)..............	ND	<0.1
Gold (Au)..................	ND	<0.05
Boron (B)..................	0.06	<0.01
Chromium (Cr)..............	ND	<0.02
Copper (Cu)................	ND	<0.01
Iron (Fe)..................	0.07	<0.05
Manganese (Mn).............	2.01	<0.02
Strontium (Sr).............	7.54	<0.05
Zinc (Zn)..................	0.75	<0.01

ND - Analyte "not detected" at the stated detection limit.

Mary Stepp

Mary Stepp
Lab Director

Inter-Mountain
Laboratories, Inc.

2506 West Main Street
Farmington, New Mexico 87401
Tel: (505) 326-4737

CLIENT:	Sunnyside Gold	DATE REPORTED:	04/10/91
ID:	1310		
SITE:	Wash HW	DATE RECEIVED:	03/18/91
LAB NO:	F5909	DATE COLLECTED:	03/13/91

Lab pH (s.u.)	7.17
Lab conductivity, umhos/cm	1990
Lab resistivity, ohm-m	5.03
Total dissolved solids (180), mg/l	1920
Total dissolved solids (calc), mg/l	1650
Total suspended solids, mg/l	2
Total alkalinity as CaCO3, mg/l	59.8
Total hardness as CaCO3, mg/l	1250
Sodium absorption ratio	0.185
Total ortho-phosphate, mg/l	<0.02
Fluoride, mg/l	2.27
Total nitrate and nitrite, mg/l	<0.04
Ammonia, mg/l	<0.02

	mg/l	meq/l
Bicarbonate as HCO3	73.2	1.2
Carbonate as CO3	0	0
Chloride	2.04	0.06
Sulfate	1230	25.5
Calcium	174	8.7
Magnesium	198	16.3
Potassium	1.11	0.03
Sodium	15	0.65
Major cations		25.7
Major anions		26.8
Cation/anion difference		2.17 %

Inter-Mountain
Laboratories, Inc.

2506 West Main Street
Farmington, New Mexico 87401
Tel. (505) 326-4737

CLIENT: Sunnyside Gold
ID: 1310
SITE: Wash HW
LAB NO: F5909

DATE REPORTED: 04/10/91
DATE RECEIVED: 03/18/91
DATE COLLECTED: 03/13/91

Trace metals by AA (dissolved concentration), mg/l

	Analytical Result:	Detection Limit:
Arsenic (As)................	ND	<0.005
Cadmium (Cd)................	ND	<0.002
Mercury (Hg)................	ND	<0.001
Lead (Pb)...................	ND	<0.005
Selenium (Se)...............	ND	<0.005

Trace metals by ICAP (dissolved concentration), mg/l

	Analytical Result:	Detection Limit:
Silver (Ag).................	ND	<0.01
Aluminum (Al)...............	ND	<0.1
Gold (Au)...................	ND	<0.05
Boron (B)...................	0.05	<0.01
Chromium (Cr)...............	ND	<0.02
Copper (Cu).................	ND	<0.01
Iron (Fe)...................	0.06	<0.05
Manganese (Mn)..............	2.21	<0.02
Strontium (Sr)..............	7.29	<0.05
Zinc (Zn)...................	0.98	<0.01

ND - Analyte "not detected" at the stated detection limit.

Mary Stepp

Mary Stepp
Lab Director

ROOT & NORTON LABORATORIES
SILVERTON, COLORADO 81433

P.O. BOX 309
303-387-5492

CERTIFICATE OF WATER ANALYSIS

CLIENT: SJCMV - Sunnyside Mine
REPORT DATE: 3/18/91
SAMPLE ID: WASH HW
LAB ID: AT1417
SAMPLE DATE: 3/13/91 TIME: 1:10
SAMPLED BY: EB DATE REC'D: 3/13 ANALYZED: 3/14

PARAMETERS	SAMPLE VALUE		% RSD		SPIKE RECOVERY		CONTROL RECOVERY	
TEMPERATURE		C.						
pH	7.53	s.u.						
T. SUSPENDED SLDS	0.22	mg/L						
T. DISSOLVED SLDS		mg/L						
CONDUCTIVITY .... (/cm @ 25 C)		umhos						
T. HARDNESS .... (as CaCO3-EDTA)		mg/L						
T. LEAD	0.15	mg/L	20.0	%	98	%	106	%
T. COPPER	0.02	mg/L	50.0	%	85	%	93	%
T. ZINC	0.95	mg/L	1.0	%	100	%	106	%
T. CADMIUM	0.002	mg/L	24.0	%	98	%	92	%
T. CHROMIUM		mg/L		%		%		%
T. MANGANESE.....	2.18	mg/L	0.5	%	105	%	97	%
T. IRON	0.22	mg/L	2.3	%	89	%	90	%
T. CYANIDE		mg/L		%		%		%
T. MERCURY		mg/L		%		%		%

Metals Digestion: Total Recoverable

Remarks:

CERTIFIED BY: Charges $ 49.00

Inter-Mountain Laboratories, Inc.

2506 West Main Street
Farmington, New Mexico 87401
Tel. (505) 326-4737

CLIENT:	Sunnyside Gold	DATE REPORTED:	03/27/91
ID:	0945		
SITE:	West Drift	DATE RECEIVED:	03/07/91
LAB NO:	F5880	DATE COLLECTED:	03/05/91

Lab pH (s.u.)	6.71
Lab conductivity, umhos/cm	1740
Lab resistivity, ohm-m	5.73
Total dissolved solids (180), mg/l	1820
Total dissolved solids (calc), mg/l	1670
Total suspended solids, mg/l	56
Total alkalinity as CaCO3, mg/l	51.3
Total hardness as CaCO3, mg/l	1240
Sodium absorption ratio	0.073
Total ortho-phosphate, mg/l	0.02
Fluoride, mg/l	7.08
Total nitrate and nitrite, mg/l	<0.04
Ammonia, mg/l	0.06

	mg/l	meq/l
Bicarbonate as HCO3	62.8	1.03
Carbonate as CO3	0	0
Chloride	4.08	0.12
Sulfate	1150	24
Calcium	434	21.6
Magnesium	38.2	3.15
Potassium	0.81	0.02
Sodium	5.9	0.26
Major cations		25.1
Major anions		25.1
Cation/anion difference		0.14 %

Inter-Mountain Laboratories, Inc.

2506 West Main Street
Farmington, New Mexico 87401
Tel. (505) 326-4737

CLIENT:	Sunnyside Gold	DATE REPORTED:	03/28/91
ID:	0945		
SITE:	West Drift	DATE RECEIVED:	03/07/91
LAB NO:	F5880	DATE COLLECTED:	03/05/91

Trace metals by AA (dissolved concentration), mg/l

	Analytical Result:	Detection Limit:
Arsenic (As)................	ND	<0.005
Cadmium (Cd)................	0.082	<0.0002
Mercury (Hg)................	ND	<0.001
Lead (Pb)................	ND	<0.005
Selenium (Se)................	ND	<0.005

Trace metals by ICAP (dissolved concentration), mg/l

	Analytical Result:	Detection Limit:
Silver (Ag)................	ND	<0.01
Aluminum (Al)................	0.5	<0.1
Gold (Au)................	ND	<0.05
Boron (B)................	ND	<0.05
Chromium (Cr)................	ND	<0.02
Copper (Cu)................	ND	<0.01
Iron (Fe)................	5.47	<0.05
Manganese (Mn)................	17.7	<0.02
Strontium (Sr)................	4.68	<0.05
Zinc (Zn)................	17.9	<0.01

ND - Analyte "not detected" at the stated detection limit.

Mary Stepp

Mary Stepp
Lab Director

ROOT & NORTON LABORATORIES
SILVERTON, COLORADO 81433

P.O. BOX 309
303-387-5492

CERTIFICATE OF WATER ANALYSIS

CLIENT: SJCMV - Sunnyside Mine
REPORT DATE: 3/8/91
SAMPLE ID: West Drift
LAB ID: AT1398
SAMPLE DATE: 3/5/91 TIME: 9:45 am
SAMPLED BY: EB DATE REC'D: 3/5 ANALYZED: 3/6

PARAMETERS	SAMPLE VALUE		% RSD		SPIKE RECOVERY	CONTROL RECOVERY	
TEMPERATURE		C.					
pH	6.73	s.u.					
T. SUSPENDED SLDS	70.7	mg/L					
T. DISSOLVED SLDS		mg/L					
CONDUCTIVITY .... (/cm @ 25 C)		umhos					
T. HARDNESS .... (as CaCO3-EDTA)		mg/L					
T. LEAD	0.24	mg/L	12.6	%	%	91	%
T. COPPER	0.205	mg/L	3.1	%	%	104	%
T. ZINC	16.70	mg/L	4.5	%	%	100	%
T. CADMIUM	0.106	mg/L	1.1	%	%	79	%
T. CHROMIUM		mg/L		%	%		%
T. MANGANESE.....	18.65	mg/L	0.9	%	%	103	%
T. IRON	15.5	mg/L	1.6	%	%	92	%
T. CYANIDE		mg/L		%	%		%
T. MERCURY		mg/L		%	%		%

Metals Digestion: Total Recoverable

Remarks:

CERTIFIED BY: ______________________ Charges $ 49.00

RÓOT & NORTON LABORATORIES
SILVERTON, COLORADO 81433

P.O. BOX 309
303-387-5492

CERTIFICATE OF WATER ANALYSIS

CLIENT: SJCMV - Sunnyside Mine   REPORT DATE: 3/8/91
SAMPLE ID: Wash FW   LAB ID: AT1399
SAMPLE DATE: 3/5/91   TIME: 8:50 am
SAMPLED BY: EB   DATE REC'D: 3/5   ANALYZED: 3/6

PARAMETERS	SAMPLE VALUE		% RSD		SPIKE RECOVERY	CONTROL RECOVERY	
TEMPERATURE		C.					
pH	7.68	s.u.					
T. SUSPENDED SLDS	5.62	mg/L					
T. DISSOLVED SLDS		mg/L					
CONDUCTIVITY .... (/cm @ 25 C)		umhos					
T. HARDNESS .... (as CaCO3-EDTA)		mg/L					
T. LEAD	0.21	mg/L	10.1	%	%	91	%
T. COPPER	0.13	mg/L	5.4	%	%	101	%
T. ZINC	33.43	mg/L	3.1	%	%	100	%
T. CADMIUM	0.090	mg/L	4.9	%	%	79	%
T. CHROMIUM		mg/L		%	%		%
T. MANGANESE.....	64.29	mg/L	1.1	%	%	92	%
T. IRON	0.38	mg/L	6.2	%	%	102	%
T. CYANIDE		mg/L		%	%		%
T. MERCURY		mg/L		%	%		%

Metals Digestion: Total Recoverable

Remarks:

CERTIFIED BY: ____________________ Charges $ 49.00

iml
Inter-Mountain
Laboratories, Inc.

2506 West Main Street
Farmington, New Mexico 87401
Tel. (505) 326-4737

CLIENT:	Sunnyside Gold	DATE REPORTED:	03/28/91
ID:	0850		
SITE:	Wash FW	DATE RECEIVED:	03/07/91
LAB NO:	F5882	DATE COLLECTED:	03/06/91

Lab pH (s.u.)	7.24
Lab conductivity, umhos/cm	1850
Lab resistivity, ohm-m	5.4
Total dissolved solids (180), mg/l	1840
Total dissolved solids (calc), mg/l	1700
Total suspended solids, mg/l	1
Total alkalinity as CaCO3, mg/l	133
Total hardness as CaCO3, mg/l	1270
Sodium absorption ratio	0.076
Total ortho-phosphate, mg/l	<0.02
Fluoride, mg/l	4.19
Total nitrate and nitrite, mg/l	0.04
Ammonia, mg/l	0.06

	mg/l	meq/l
Bicarbonate as HCO3	163	2.67
Carbonate as CO3	0	0
Chloride	4.08	0.12
Sulfate	1130	23.5
Calcium	430	21.5
Magnesium	47.7	3.92
Potassium	1.44	0.04
Sodium	6.2	0.27
Major cations		25.7
Major anions		26.3
Cation/anion difference		1.25 %

Inter-Mountain Laboratories, Inc.

2506 West Main Street
Farmington, New Mexico 87401
Tel. (505) 326-4737

CLIENT: Sunnyside Gold
ID: 0850
SITE: Wash FW
LAB NO: F5862

DATE REPORTED: 03/28/91
DATE RECEIVED: 03/07/91
DATE COLLECTED: 03/05/91

Trace metals by AA (dissolved concentration), mg/l

	Analytical Result:	Detection Limit:
Arsenic (As)	ND	<0.005
Cadmium (Cd)	0.073	<0.0002
Mercury (Hg)	ND	<0.001
Lead (Pb)	ND	<0.005
Selenium (Se)	ND	<0.005

Trace metals by ICAP (dissolved concentration), mg/l

	Analytical Result:	Detection Limit:
Silver (Ag)	ND	<0.01
Aluminum (Al)	0.2	<0.1
Gold (Au)	ND	<0.05
Boron (B)	0.06	<0.01
Chromium (Cr)	ND	<0.02
Copper (Cu)	ND	<0.01
Iron (Fe)	ND	<0.05
Manganese (Mn)	61.9	<0.02
Strontium (Sr)	3.99	<0.05
Zinc (Zn)	34.3	<0.01

ND - Analyte "not detected" at the stated detection limit.

Mary Stepp

Mary Stepp
Lab Director

Client : Sunnyside Mine
Address : #1 Gladstone
Silverton, CO 81433
Attn. : Mr. E. Bingham
Project :
Sample Matrix:
Sample ID: Ross Basin Seep
Lab No. : 91-WI/09316
Sample Date Time: 10/17/91 15:00
Date Received: 10/21/91

RECEIVED
NOV 07 1991
HYDRO-SEARCH, INC.-RENO

Parameters

Cadmium, dissolved	-.005	mg/l
Copper, dissolved	-.01	mg/l
Iron, dissolved	.15	mg/l
Lead, dissolved	.04	mg/l
Manganese, dissolved	.44	mg/l
Zinc, dissolved	.44	mg/l

Remarks:
Note: Negative sign "-" denotes that the value is less than "<"

Frank E. Polniak, Inorganic Lab Supervisor

Ralph V. Poulsen for FP

ROOT & NORTON LABORATORIES
SILVERTON, COLORADO 81433

P.O. BOX 309
303-387-5492

CERTIFICATE OF WATER ANALYSIS

CLIENT: SJCMV - Sunnyside Mine
REPORT DATE: 3/8/91
SAMPLE ID: Fault #1
LAB ID: AT1401
SAMPLE DATE: 3/5/91 TIME: 11:35 am
SAMPLED BY: EB DATE REC'D: 3/5 ANALYZED: 3/6

PARAMETERS	SAMPLE VALUE		% RSD		SPIKE RECOVERY		CONTROL RECOVERY	
TEMPERATURE		C.						
pH	5.90	s.u.						
T. SUSPENDED SLDS	4.78	mg/L						
T. DISSOLVED SLDS		mg/L						
CONDUCTIVITY .... (/cm @ 25 C)		umhos						
T. HARDNESS .... (as CaCO3-EDTA)		mg/L						
T. LEAD	0.21	mg/L	7.6	%	107	%	92	%
T. COPPER	0.34	mg/L	3.7	%	92	%	104	%
T. ZINC	47.08	mg/L	1.0	%		%	100	%
T. CADMIUM	0.064	mg/L	12.6	%		%	104	%
T. CHROMIUM		mg/L		%		%		%
T. MANGANESE.....	91.4	mg/L		%		%		%
T. IRON	344.0	mg/L	1.1	%		%	100	%
T. CYANIDE		mg/L		%		%		%
T. MERCURY		mg/L		%		%		%

Metals Digestion: Total Recoverable

Remarks:

CERTIFIED BY: ______________________ Charges $ 49.00

ROOT & NORTON LABORATORIES
SILVERTON, COLORADO 81433

P.O. BOX 309
303-387-5492

CERTIFICATE OF WATER ANALYSIS

CLIENT: SJCMV - Sunnyside Mine
SAMPLE ID: Fault #2
SAMPLE DATE: 3/5/91 TIME: 11:50 am
SAMPLED BY: EB DATE REC'D: 3/5 ANALYZED: 3/6

REPORT DATE: 3/8/91
LAB ID: AT1402

PARAMETERS	SAMPLE VALUE		% RSD	SPIKE RECOVERY	CONTROL RECOVERY
TEMPERATURE		C.			
pH	6.05	s.u.			
T. SUSPENDED SLDS	4.88	mg/L			
T. DISSOLVED SLDS		mg/L			
CONDUCTIVITY .... (/cm @ 25 C)		umhos			
T. HARDNESS .... (as CaCO3-EDTA)		mg/L			
T. LEAD	0.59	mg/L	6.4 %	%	94 %
T. COPPER	0.03	mg/L	10.5 %	%	101 %
T. ZINC	70.1	mg/L	1.2 %	%	100 %
T. CADMIUM	0.106	mg/L	9.1 %	%	104 %
T. CHROMIUM		mg/L	%	%	%
T. MANGANESE.....	132.6	mg/L	0.0 %	%	%
T. IRON	531.0	mg/L	0.9 %	%	103 %
T. CYANIDE		mg/L	%	%	%
T. MERCURY		mg/L	%	%	%

Metals Digestion: Total Recoverable

Remarks:

CERTIFIED BY: ______________________ Charges $ 49.00

Inter-Mountain Laboratories, Inc.

2506 West Main Street
Farmington, New Mexico 87401
Tel. (505) 326-4737

CLIENT:	Sunnyside Gold	DATE REPORTED:	03/28/91
ID:	1150		
SITE:	Fault #2	DATE RECEIVED:	03/07/91
LAB NO:	F5879	DATE COLLECTED:	03/05/91

Trace metals by AA (dissolved concentration), mg/l

	Analytical Result:	Detection Limit:
Arsenic (As)................	ND	<0.005
Cadmium (Cd)................	0.089	<0.0002
Mercury (Hg)................	ND	<0.001
Lead (Pb)..................	0.425	<0.004
Selenium (Se)...............	ND	<0.005

Trace metals by ICAP (dissolved concentration), mg/l

	Analytical Result:	Detection Limit:
Silver (Ag).................	ND	<0.01
Aluminum (Al)...............	22.3	<0.1
Gold (Au)...................	ND	<0.05
Boron (B)...................	ND	<0.01
Chromium (Cr)...............	ND	<0.02
Copper (Cu).................	ND	<0.01
Iron (Fe)...................	537.	<0.05
Manganese (Mn)..............	151.	<0.02
Strontium (Sr)..............	5.89	<0.05
Zinc (Zn)...................	92.1	<0.01

ND - Analyte "not detected" at the stated detection limit.

Mary Stepp

Mary Stepp
Lab Director

2506 W. Main Street
Farmington, New Mexico 87401

Client: Sunnyside Gold Corp.

Site: ATINFL -ATO
IML #: F7491

Date of report: 10/28/91
Date received: 10/07/91
Date sampled: 10/02/91
Time sampled: 1035

	Result:	Date analyzed
Lab pH	5.56	10/14/91
Total dissolved solids (180), mg/L	1914	10/15/91
Total suspended solids, mg/L	83	10/09/91
Total cadmium, mg/L	0.22	
Total copper, mg/L	0.22	
Total lead, mg/L	<0.005	
Total mercury, mg/L	<0.0002	
Total zinc, mg/L	13.2	
Total iron, mg/L	35.0	
Total manganese, mg/L	20.2	

* TSS reanalyzed on the same day 76 mg/L.

Mary Stepp
Mary Stepp
Lab Director

Wanda Orso
Wanda Orso
Water Lab Supervisor

2506 W. Main Street
Farmington, New Mexico 87401

Client:	Sunnyside Gold Corp.	Date of report:	10/28/91
		Date received:	10/07/91
Site:	AT 2400	Date sampled:	10/02/91
IML #:	F7490	Time sampled:	1145

	Result:	Date analyzed
Lab pH	5.56	10/14/91
Total dissolved solids (180), mg/L	1960	10/15/91
Total suspended solids, mg/L	87	10/09/91
Total cadmium, mg/L	0.06	
Total copper, mg/L	0.22	
Total lead, mg/L	<0.005	
Total mercury, mg/L	<0.0002	
Total zinc, mg/L	14.4	
Total iron, mg/L	39.8	
Total manganese, mg/L	22.2	

* TSS reanalyzed on the same day 91 mg/L.

Mary Stepp
Mary Stepp
Lab Director

Wanda Orso
Wanda Orso
Water Lab Supervisor

2506 W. Main Street
Farmington, New Mexico 87401

Client:	Sunnyside Gold Corp.	Date of report:	10/28/91
		Date received:	10/07/91
Site:	AT 2700	Date sampled:	10/02/91
IML #:	F7489	Time sampled:	1220

	Result:	Date analyzed
Lab pH................................	5.68	10/14/91
Total dissolved solids (180), mg/L..	1932	10/15/91
Total suspended solids, mg/L........	92	10/09/91
Total cadmium, mg/L.................	0.066	
Total copper, mg/L..................	0.24	
Total lead, mg/L....................	<0.005	
Total mercury, mg/L.................	<0.0002	
Total zinc, mg/L....................	14.4	
Total iron, mg/L....................	39.8	
Total manganese, mg/L...............	22.2	

* TSS reanalyzed on the same day 90 mg/L.

Mary Stepp
Lab Director

Wanda Orso
Water Lab Supervisor

2506 W. Main Street
Farmington, New Mexico 87401

Client: Sunnyside Gold Corp.

Site: AT 3450
IML #: F7488

Date of report: 10/28/91
Date received: 10/07/91
Date sampled: 10/02/91
Time sampled: 1425

	Result:	Date analyzed
Lab pH	7.17	10/14/91
Total dissolved solids (180), mg/L	1790	10/15/91
Total suspended solids, mg/L	34	10/09/91
Total cadmium, mg/L	0.70	
Total copper, mg/L	0.30	
Total lead, mg/L	<0.005	
Total mercury, mg/L	<0.0002	
Total zinc, mg/L	12.2	
Total iron, mg/L	10.7	
Total manganese, mg/L	17.1	

* TSS reanalyzed on the same day 30 mg/L.

Mary Stepp
Mary Stepp
Lab Director

Wanda Orso
Wanda Orso
Water Lab Supervisor

2506 W. Main Street
Farmington, New Mexico 87401

Client:	Sunnyside Gold Corp.	Date of report:	10/28/91
		Date received:	10/07/91
Site:	AT 6400	Date sampled:	10/02/91
IML #:	F7486	Time sampled:	1515

	Result:	Date analyzed
Lab pH..............................	7.23	10/14/91
Total dissolved solids (180), mg/L..	1780	10/15/91
Total suspended solids, mg/L........	31	10/09/91
Total cadmium, mg/L.................	0.074	
Total copper, mg/L..................	0.32	
Total lead, mg/L....................	<0.005	
Total mercury, mg/L.................	<0.0002	
Total zinc, mg/L....................	11.6	
Total iron, mg/L....................	5.12	
Total manganese, mg/L...............	16.0	

* TSS reanalyzed on the same day 31 mg/L.

Mary Stepp
Mary Stepp
Lab Director

Wanda Orso
Wanda Orso
Water Lab Supervisor

2506 W. Main Street
Farmington, New Mexico 87401

Client:	Sunnyside Gold Corp.	Date of report:	10/28/91
		Date received:	10/07/91
Site:	AT 7350	Date sampled:	10/02/91
IML #:	F7487	Time sampled:	1600

	Result:	Date analyzed
Lab pH..................................	7.15	10/14/91
Total dissolved solids (180), mg/L..	1724	10/15/91
Total suspended solids, mg/L........	20	10/09/91
Total cadmium, mg/L.................	0.088	
Total copper, mg/L..................	0.42	
Total lead, mg/L....................	<0.005	
Total mercury, mg/L.................	<0.0002	
Total zinc, mg/L....................	16.4	
Total iron, mg/L....................	7.06	
Total manganese, mg/L...............	21.8	

* TSS reanalyzed on the same day 20 mg/L.

Mary Stepp
Mary Stepp
Lab Director

Wanda Orso
Wanda Orso
Water Lab Supervisor

2506 W. Main Street
Farmington, New Mexico 87401

Client: Sunnyside Gold Corp.

Site: TT002
IML #: F7492

Date of report: 10/28/91
Date received: 10/07/91
Date sampled: 10/03/91
Time sampled: 0915

	Result:	Date analyzed
Lab pH	6.42	10/14/91
Total dissolved solids (180), mg/L	994	10/15/91
Total suspended solids, mg/L	20	10/09/91
Total cadmium, mg/L	0.0073	
Total copper, mg/L	0.05	
Total lead, mg/L	0.006	
Total mercury, mg/L	<0.0002	
Total zinc, mg/L	0.53	
Total iron, mg/L	0.31	
Total manganese, mg/L	18.82	
Total silver, mg/L	<0.01	
Dissolved cadmium, mg/L	0.0049	
Dissolved copper, mg/L	0.03	
Dissolved lead, mg/L	<0.005	
Dissolved mercury, mg/L	<0.0002	
Dissolved zinc, mg/L	0.42	
Dissolved iron, mg/L	0.28	
Dissolved manganese, mg/L	6.14	
Dissolved silver, mg/L	<0.01	

* TSS reanalyzed on the same day 19 mg/L.

Mary Stepp
Mary Stepp
Lab Director

Wanda Orso
Wanda Orso
Water Lab Supervisor

2506 W. Main Street
Farmington, New Mexico 87401

Client:	Sunnyside Gold Corp.	Date of report:	10/28/91
		Date received:	10/07/91
Site:	AT8150DH	Date sampled:	10/03/91
IML #:	F7485	Time sampled:	1145

	Result:	Date analyzed
Lab pH..............................	6.96	10/14/91
Total dissolved solids (180), mg/L..	1716	10/15/91
Total suspended solids, mg/L........	34	10/09/91
Total cadmium, mg/L.................	0.102	
Total copper, mg/L..................	0.52	
Total lead, mg/L....................	<0.005	
Total mercury, mg/L.................	<0.0002	
Total zinc, mg/L....................	18.6	
Total iron, mg/L....................	8.62	
Total manganese, mg/L...............	26.0	

* TSS reanalyzed on the same day 34 mg/L.

Mary Stepp
Mary Stepp
Lab Director

Wanda Orso
Wanda Orso
Water Lab Supervisor

2506 W. Main Street
Farmington, New Mexico 87401

Client:	Sunnyside Gold Corp.	Date of report:	10/28/91
		Date received:	10/07/91
Site:	AT HW 5	Date sampled:	10/03/91
IML #:	F7484	Time sampled:	1335

	Result:	Date analyzed
Lab pH..............................	7.58	10/14/91
Total dissolved solids (180), mg/L..	1918	10/15/91
Total suspended solids, mg/L........	3	10/09/91
Total cadmium, mg/L.................	0.0023	
Total copper, mg/L..................	0.01	
Total lead, mg/L....................	<0.005	
Total mercury, mg/L.................	<0.0002	
Total zinc, mg/L....................	1.30	
Total iron, mg/L....................	0.36	
Toital manganese, mg/L..............	2.96	

* TSS reanalyzed on the same day 4 mg/L.

Mary Stepp
Mary Stepp
Lab Director

Wanda Orso
Wanda Orso
Water Lab Supervisor

2506 W. Main Street
Farmington, New Mexico 87401

Client:	Sunnyside Gold Corp.	Date of report:	10/28/91
		Date received:	10/07/91
Site:	AT West 4	Date sampled:	10/03/91
IML #:	F7481	Time sampled:	1515

	Result:	Date analyzed
Lab pH................................	6.64	10/14/91
Total dissolved solids (180), mg/L..	1762	10/15/91
Total suspended solids, mg/L........	76	10/09/91
Total cadmium, mg/L.................	0.126	
Total copper, mg/L..................	0.14	
Total lead, mg/L....................	<0.005	
Total mercury, mg/L.................	<0.0002	
Total zinc, mg/L....................	18.6	
Total iron, mg/L....................	18.6	
Total manganese, mg/L...............	19.1	

* TSS reanalyzed on the same day 64 mg/L.

Mary Stepp
Mary Stepp
Lab Director

Wanda Orso
Wanda Orso
Water Lab Supervisor

2506 W. Main Street
Farmington, New Mexico 87401

Client:	Sunnyside Gold Corp.	Date of report:	10/28/91
		Date received:	10/07/91
Site:	AT FW 4	Date sampled:	10/03/91
IML #:	F7482	Time sampled:	1430

	Result:	Date analyzed
Lab pH..............................	2.94	10/14/91
Total dissolved solids (180), mg/L..	4680	10/15/91
Total suspended solids, mg/L........	144	10/09/91
Total cadmium, mg/L.................	1.42	
Total copper, mg/L..................	12.80	
Total lead, mg/L....................	<0.005	
Total mercury, mg/L.................	<0.0002	
Total zinc, mg/L....................	347.8	
Total iron, mg/L....................	69.6	
Total manganese, mg/L...............	433.6	

* TSS reanalyzed on the same day 144 mg/L.

Mary Stepp
Mary Stepp
Lab Director

Wanda Orso
Wanda Orso
Water Lab Supervisor

2506 W. Main Street
Farmington, New Mexico 87401

Client:	Sunnyside Gold Corp.	Date of report:	10/28/91
		Date received:	10/07/91
Site:	AT SS 3	Date sampled:	10/03/91
IML #:	F7483	Time sampled:	1230

	Result:	Date analyzed
Lab pH	7.35	10/14/91
Total dissolved solids (180), mg/L	1288	10/15/91
Total suspended solids, mg/L	7	10/09/91
Total cadmium, mg/L	0.0071	
Total copper, mg/L	0.02	
Total lead, mg/L	<0.005	
Total mercury, mg/L	0.0005	
Total zinc, mg/L	1.64	
Total iron, mg/L	0.41	
Total manganese, mg/L	5.24	

* TSS reanalyzed on the same day 8 mg/L.

Mary Stepp
Mary Stepp
Lab Director

Wanda Orso
Wanda Orso
Water Lab Supervisor

SIMON HYDRO-SEARCH

5250 South Virginia Street
Suite 280
Reno, NV 89502

Telephone (702) 829-1200
(800) 347-4937
Facsimile (702) 829-1243

Evaluation of Hydraulic and Hydrochemical Aspects of Proposed Bulkheads Sunnyside Mine San Juan County, Colorado

March 12, 1993

Prepared for:

Sunnyside Gold Corporation

Prepared by:

Simon Hydro-Search
5250 South Virginia Street, Suite 280
Reno, Nevada 89502

201872025

Robert O. Walston, P.E.
Geological Engineer

Mark D. Stock
Senior Hydrogeologist
Project Manager

Charles Norris
Director of Hydrogeology

sunny\wp\traci\2251\Mar1993.Rpt

SIMON Environmental

TABLE OF CONTENTS

TABLE OF CONTENTS, Con't.

FIGURES

TABLE OF CONTENTS, Con't.

SECTION PAGE

TABLES

APPENDICES

TABLE OF CONTENTS, Con't.

1.0 EXECUTIVE SUMMARY

The Sunnyside Mine is located approximately 8 miles north of Silverton, Colorado, in northernmost San Juan County. Slightly acidic water with mobilized heavy metals flows from both access tunnels to the mine. Sunnyside Gold Corporation (SGC) proposes to install underground bulkheads in order to contain mine drainage and allow a return to an approximation of pre-mine hydrologic conditions. This report estimates the influence that local hydrogeology will have on the effectiveness of the proposed bulkheads, the impact that the proposed bulkheads will have on the ground-water flow system, and the probable effects that installing the proposed bulkheads will have on the hydrochemistry of ground water and surface water in the vicinity of the Sunnyside Mine.

In the vicinity of the Sunnyside Mine, ground water moves through fractures. Permeability in the area is anisotropic, with greater permeability in a northeast/southwest direction due to the dominant fracture orientation in the Eureka graben. The original direction of ground water movement appears to have been from the Sunnyside Basin (where the Sunnyside Mine workings are) towards Cement Creek. The original ground-water flow direction is expected to eventually be reestablished if the proposed bulkheads are installed.

Flow testing of boreholes in the American Tunnel yielded an estimated hydraulic conductivity of 5×10^{-5} cm/sec (0.15 feet/day). However, rock in the vicinity of the flow tests exhibits more fracture permeability than is typical for the American Tunnel, so this estimated hydraulic conductivity may be higher than the general average. Laboratory measurement of intergranular hydraulic conductivities of core from proposed bulkhead sites showed a range from 10^{-8} to 10^{-10} cm/sec. Laboratory measurement of two fractured cores, which appear to represent local blast damage, showed hydraulic conductivity on the order of 10^{-6} cm/sec.

The Sunnyside Mine workings are expected to fill with water until an equilibrium is reached between water flowing into the mine workings and water leaving the mine workings via natural fracture pathways. Based on historical information the equilibrium water level is expected to be approximately at F level (11,500 feet msl). Once a bulkhead is installed in the American Tunnel, it is estimated that the water level will substantially reach equilibrium (86% of equilibrium) in approximately 10 years.

The rate of leakage through the bedrock in the immediate vicinity of each proposed bulkhead is expected to be less than 1 gpm. However, if the permeability and equilibrium water level are both higher than anticipated, such leakage through the bedrock could be as much as 25 gpm.

The overall, generalized flow through the flooded mine workings to the surface along natural fractures is expected to be approximately 70 gpm, but could be as great as 200 gpm. The discharge to the surface is expected to occur primarily along Cement Creek between the Mogul Mine (to the north) and the Silver Ledge Mine (on the south). The discharge is expected to be diffuse rather than concentrated at one spring. However, if the equilibrium water level in the flooded mine workings is much higher than anticipated (12,250 feet msl), up to an additional 160 gpm could discharge via the Mogul Mine. The travel time from the flooded workings to Cement Creek is estimated at approximately 150 years. Under the unlikely scenario that the equilibrium water level in the flooded workings is at 12,250 feet msl, some of the water could reach Cement Creek in as little as 4 months.

The computer program MINTEQA2 was used to model the geochemistry of the rock-water reactions that are expected to result from the proposed bulkhead installations. At the American Tunnel bulkhead, the model indicates water is non-reactive with the country rock. The water behind the Terry Tunnel bulkhead is expected to be similar to the water currently discharging there. Reaction with the country rock should be minimal and will probably decrease matrix permeability with time.

In the absence of the ability to significantly oxygenate the flooded mine, the mineral load of the impounded water should be essentially that of the water that fills the mine.

basis!

This water, once equilibrated with mine minerals, is not expected to react further with vein minerals or country rock as it migrates laterally to discharge at the surface.

The modeled waters, upon discharge at the surface, will equilibrate with atmospheric carbon dioxide and oxygen. The greatest chemical change to the system will be that of changing from reduced (subsurface) waters to oxygenated (surface) waters. Oxides of most of the metals are less soluble than are the minerals associated with reduced species and most of the mineral load will be precipitated from the water. This is analogous to the process which formed the natural iron "bogs" in the area. Using conservative assumptions, the installation of these bulkheads is expected to deliver the following metals load (lbs/day) to Cement Creek: iron, <.1; manganese, <.1; zinc, 8.1 to 20.3; cadmium, .009 to .036; lead, .16 to .40; and copper, .22 to .23.

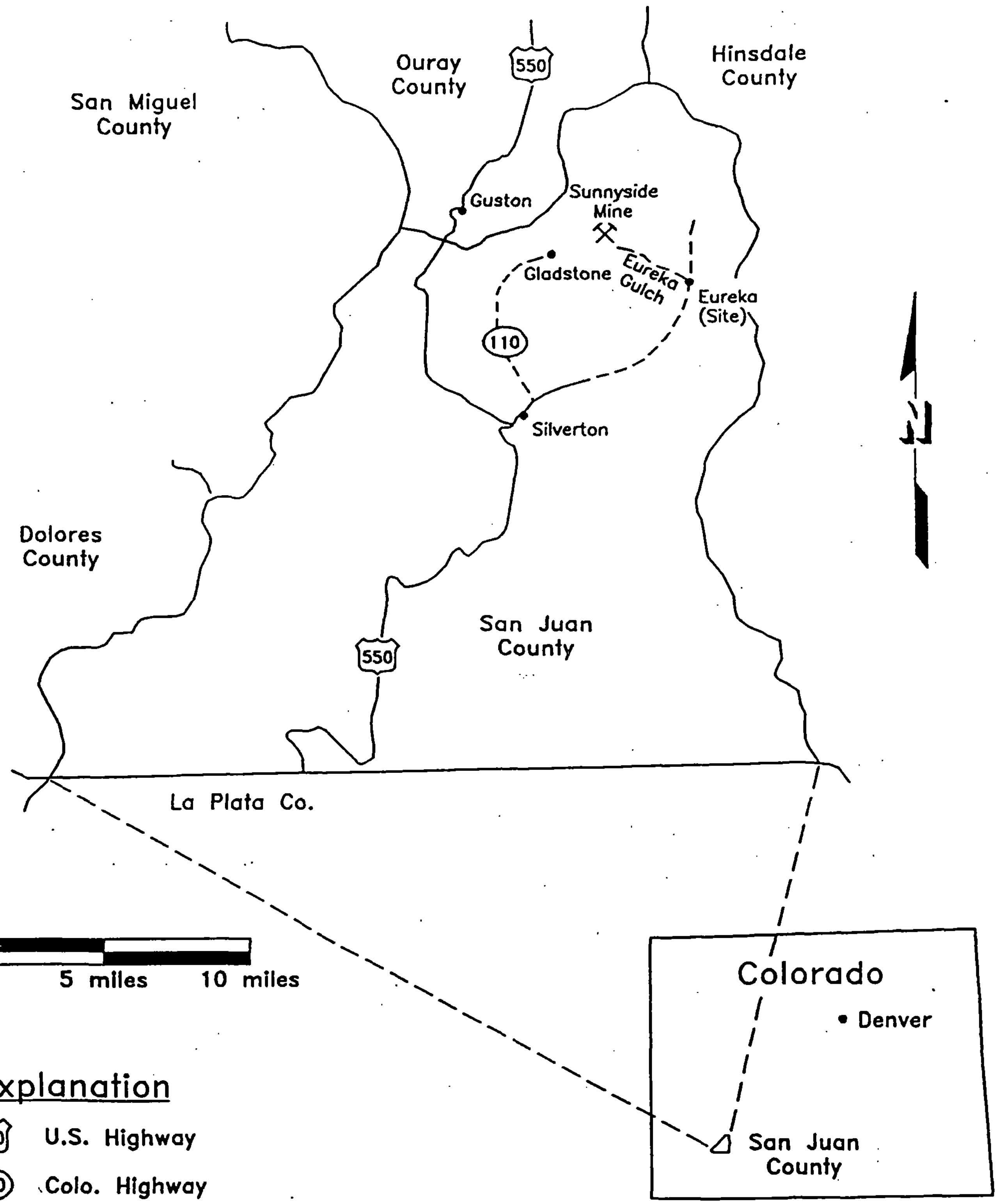
2.0 INTRODUCTION

2.1 Location and Brief Description of the Sunnyside Mine

The Sunnyside Mine is located approximately 8 miles north of Silverton in the Eureka mining district in northernmost San Juan County, Colorado (Figure 1). The Sunnyside Mine is presently owned by Sunnyside Gold Corporation (SGC), a subsidiary of Echo Bay Mines. Gold, silver, copper, lead, zinc, and cadmium ores have been produced from more than 150 miles of underground workings with a vertical extent of 2,000 feet. The majority of the mine workings are located beneath Sunnyside Basin at the head of Eureka Gulch (Figure 2). Year-round access to the main part of the mine is via the 10,000 foot long American Tunnel, the portal of which is located at an elevation of 10,617 feet at the abandoned townsite of Gladstone. Secondary access is via the Terry Tunnel located in Eureka Gulch at an elevation of approximately 11,560 feet. The jeep trail to the Terry Tunnel is impassible during winter and spring.

2.2 Statement of the Problem

Sunnyside Gold Corporation is working toward closing the Sunnyside Mine with a goal of reclaiming the mine property and reestablishing an approximation of the pre-mining hydrogeologic system. As a part of this process SGC proposes to install underground bulkheads in at least four locations in order to contain mine drainage. Drainage from the Sunnyside Mine, which presently flows out of both the American Tunnel and the Terry Tunnel, is slightly acidic and contains mobilized heavy metals (Simon Hydro-



Explanation

550 U.S. Highway

110 Colo. Highway

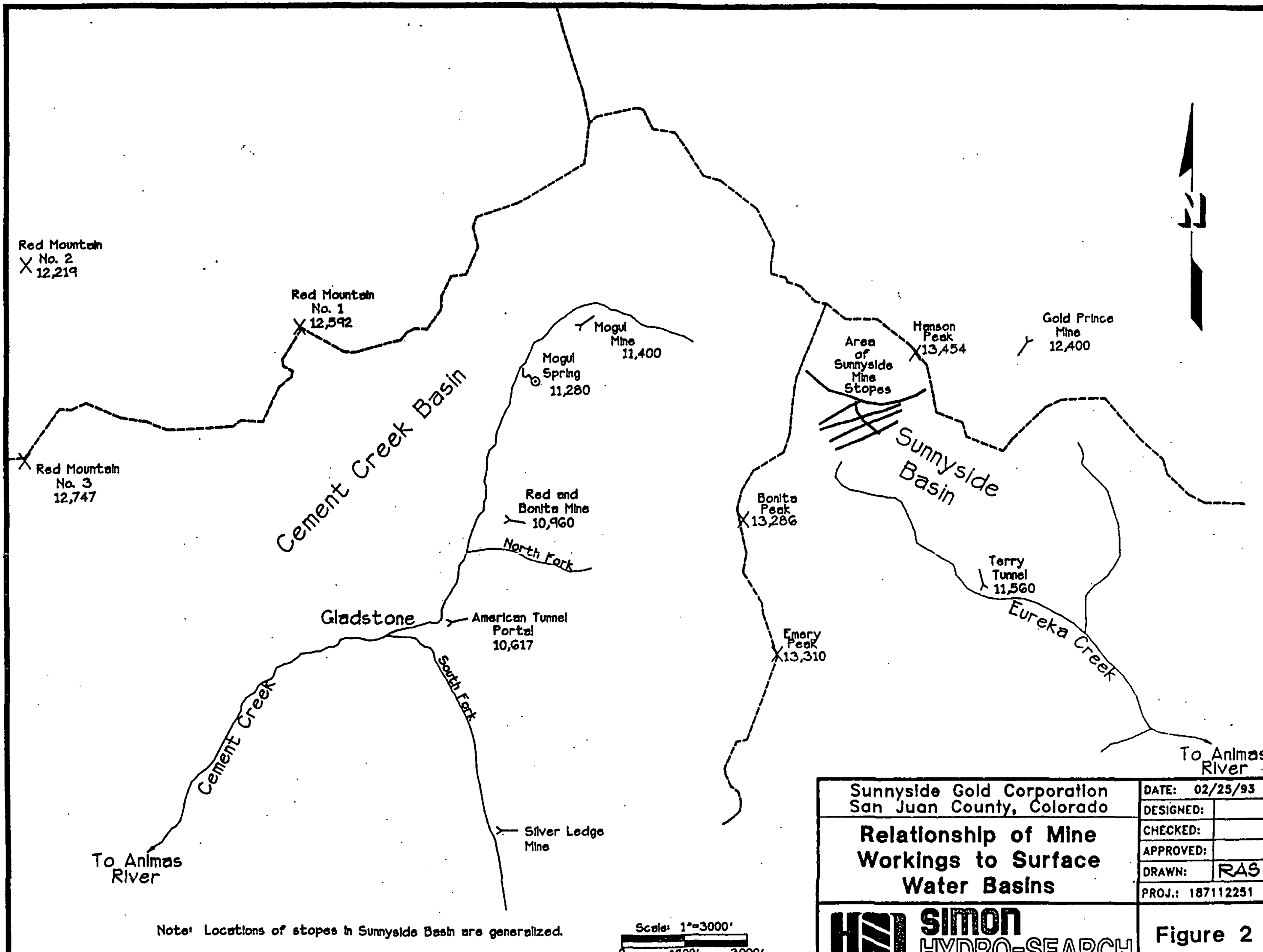
Unpaved Road

Paved Road

• Townsite

Sunnyside Gold Corporation San Juan County, Colorado	DATE: 10/7/91
	DRAWN: KEK
Location of the Sunnyside Mine	CHECKED:
	APPROVED:
	DWG NO:
	PROJ.: 46411036
Hydro-Search, Inc. HYDROLOGISTS-GEOLOGISTS-ENGINEERS Reno Denver Milwaukee Irvine	**Figure 1**

/usr2/san-juan/acad/464sm001.DWG


Red Mountain No. 2 12,219
Red Mountain No. 1 12,592
Red Mountain No. 3 12,747
Cement Creek Basin
Mogul Mine 11,400
Mogul Spring 11,280
Red and Bonita Mine 10,960
North Fork
Gladstone
American Tunnel Portal 10,617
South Fork
Cement Creek
Silver Ledge Mine
To Animas River
Area of Sunnyside Mine Stopes
Hanson Peak 13,454
Gold Prince Mine 12,400
Sunnyside Basin
Bonita Peak 13,286
Terry Tunnel 11,560
Eureka Creek
Emery Peak 13,310
To Animas River
N
Note: Locations of stopes in Sunnyside Basin are generalized.
Scale: 1"=3000'
0 1500' 3000'
Sunnyside Gold Corporation
San Juan County, Colorado
Relationship of Mine Workings to Surface Water Basins
DATE: 02/25/93
DESIGNED:
CHECKED:
APPROVED:
DRAWN: RAS
PROJ.: 187112251
SIMON HYDRO-SEARCH
Figure 2

Search, 1992). The bulkheads proposed by SGC are intended to return the ground-water system to an approximation of the flow regime which existed under natural, pre-mining, conditions.

2.3 Reports Prepared to Evaluate Impacts of Proposed Bulkheads at the Sunnyside Mine

This report estimates the influence that local hydrogeology will have on the effectiveness of the proposed bulkheads, and the impact that the proposed bulkheads will have on the ground-water flow system in the vicinity of the Sunnyside Mine. Also considered are the probable effects that installing the proposed underground bulkheads will have on the chemistry of ground water and surface water. Two other reports have been prepared to date which pertain to other aspects of the proposed bulkheads. An assessment of the natural (pre-mining) hydrologic system and present hydrology was given in "Preliminary Characterization of the Hydrology and Water Chemistry of the Sunnyside Mine and Vicinity, San Juan County, Colorado" dated February 11, 1992 by Simon Hydro-Search. Engineering aspects of the proposed bulkheads, including mechanical strength of the bulkheads and adjacent wall rock, and the chemical and physical integrity of the bulkheads, were addressed in "Bulkhead Design for the Sunnyside Mine, Sunnyside Gold Corp., An Echo Bay Company" by Dr. John F. Abel, Jr., PE.

2.4 *Purpose and Scope*

The purpose of this report is to assess the hydrogeologic and hydrochemical aspects of the proposed underground bulkheads. Specifically this report addresses:

- the likely rate of leakage in the immediate vicinity of the bulkheads;
- the anticipated equilibrium water level in the flooded mine workings;
- the approximate rate at which the mine workings will fill with water;
- the nature, rate, and timing of movement of water from flooded workings to the surface along natural and man-made pathways;
- the likely chemistry of water which would be impounded;
- the expected reactions between impounded water and country rock and mineralized veins; and
- the effects of the proposed bulkheads on the chemistry of local surface water.

This report builds upon an understanding gained during preparation of the earlier report, "Preliminary Characterization of the Hydrology and Water Chemistry of the Sunnyside Mine and Vicinity, San Juan County, Colorado" (Simon Hydro-Search, 1992). Additional work conducted in support of this report included:

- Field examinations of proposed bulkhead sites in the American Tunnel, Terry Tunnel, F-Level Brenneman vein, and B-Level Brenneman vein;
- Conducting flow tests from boreholes in the American Tunnel in order to estimate the hydraulic conductivity of the fractured volcanic rocks;
- Laboratory measurement of permeability of rock cores taken from proposed bulkhead locations;
- Detailed calculation of the volume of mine workings (in vertical increments of 100 feet) for use in estimating flooding rates;
- Simple numerical modeling of the rate of mine flooding;
- A detailed analysis of the data to estimate hydraulic aspects of the proposed bulkheads;
- Petrographic analysis of wall rock from the vicinity of proposed bulkheads;
- Collection of secondary mineralization (wall encrustations) and subsequent testing for acid-generating capacity;
- Geochemical modeling of water/rock interactions using the MINTEQA2 code; and
- A detailed analysis of water chemistry and mineralogic data to estimate the hydrochemical impacts of the proposed bulkheads.

3.0 GENERAL HYDROGEOLOGY OF THE SUNNYSIDE MINE

The general hydrogeology in the vicinity of the Sunnyside Mine was covered in "Preliminary Characterization of the Hydrology and Water Chemistry of the Sunnyside Mine and Vicinity, San Juan County, Colorado" by Simon Hydro-Search (1992). Selected aspects of that discussion are excerpted below.

3.1 Geology Pertinent to Ground-Water Flow and Chemistry

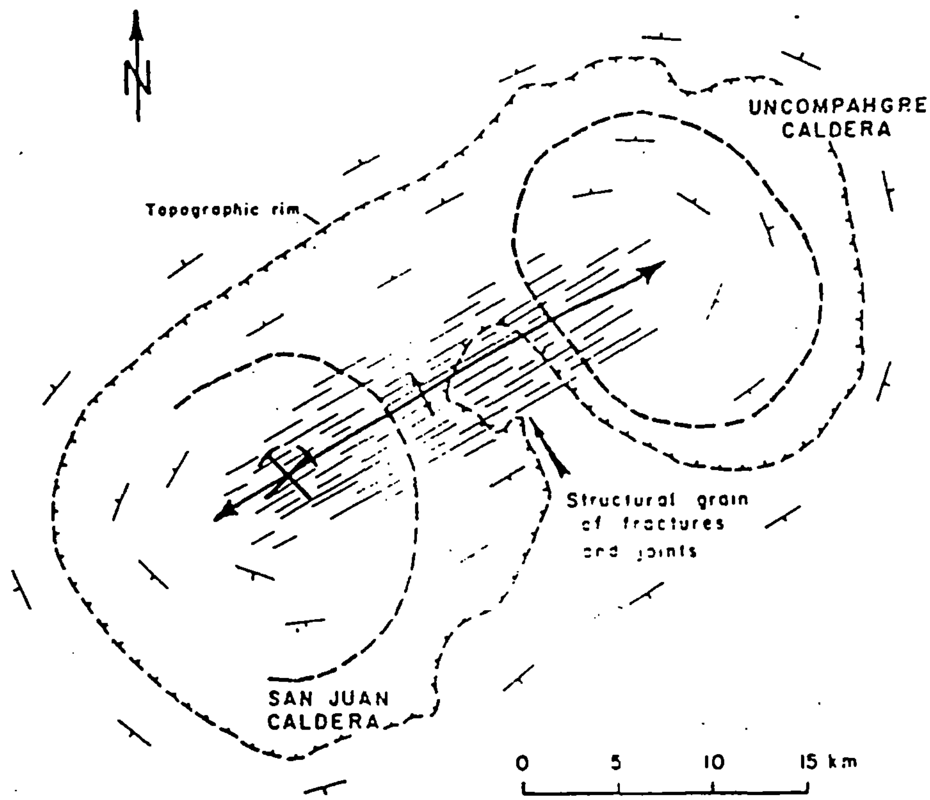
Rocks in the vicinity of the Sunnyside Mine are pyroclastics and flows which erupted from local calderas approximately 28 million years ago (Steven and Lipman, 1976). The Sunnyside Mine is principally located within the Burns Formation, which generally consists of massive silica-rich latite flows which have locally been altered and mineralized (Langston, pp. 34-39). The highest mine workings (above A level) extend into the overlying interbedded lava flows and air-fall tuffs of the Henson Formation, an alkali-rich andesite (Langston, p. 49).

The Burns Formation was erupted from vents within the San Juan caldera (Steven and Lipman, 1976, p. 11-12). The degree of welding of the upper Burns formation generally increases towards the west in the direction of the vent source (Langston, 1978, p. 11). The Henson Formation also was derived from vents located within the San Juan caldera, but typically is less welded than the Burns Formation and contains more pyroclastic units.

The extent of fracturing in volcanic rocks is directly related to the degree of welding if other factors are equal. Hence, the more welded Burns Formation tends to be more fractured than the Henson Formation.

After the deposition of the Burns and Henson formations there was a broad resurgent doming between the San Juan caldera and the Uncompahgre caldera. This resurgent doming resulted in extensive distension fracturing in a northeast/southwest-trending direction (Steven and Lipman, 1976, p. 13) as shown in Figure 3. Later collapse of the resurgent doming along steeply dipping, northeast/southwest-trending fractures formed the Eureka graben. Arcuate faults related to the collapse of the Silverton caldera (such as the Bonita fault) appear to be contemporaneous with the bounding faults of the Eureka graben. Although some later faulting exists, the Eureka graben fracture system was the last major set of fractures imprinted on the area of the Sunnyside Mine. During mineralization 13.0 to 16.6 MYBP (Casadevall and Ohmoto, 1977), the fractures of this system served as flow conduits and sites for ore deposition.

The Sunnyside Mine is located within the Eureka graben at the junction of the Ross Basin fault and the Sunnyside fault as shown in Figure 4. Figure 4 also illustrates the dominant northeast/southwest fracture trend. In the vicinity of the mine, the dip of originally horizontal strata now ranges from 10° to 14° to the southwest (Langston, 1978, p. 17).



Present location of Sunnyside Mine

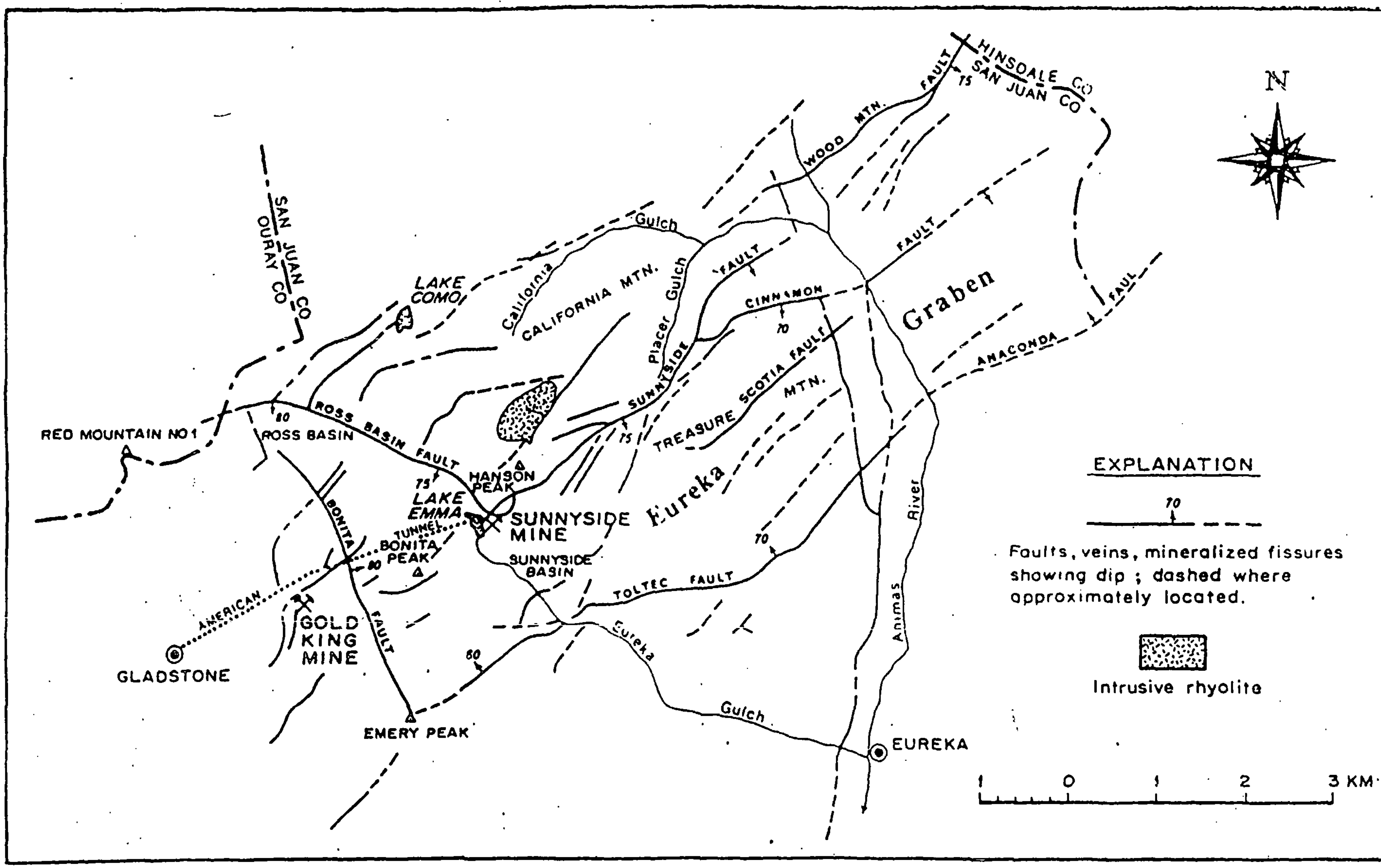
Approximate Axis of Resurgent Doming

Trend of Distension Fracture

Taken from Langston, 1978

San Juan County Mining Venture Silverton, Colorado	DATE: 10/10/9
	DRAWN: KE
Dominant Fracture System of the San Juan Caldera	CHECKED:
	APPROVED:
	DWG NO:
	PROJ.: 4641103
Hydro-Search, Inc. HYDROLOGISTS-GEOLOGISTS-ENGINEERS Reno Denver Milwaukee Irvine	Figure

G\SAN-JUAN\ACAD\4645H002.DWG



San Juan County Mining Venture Silverton, Colorado	DATE: 10/10/91
	DRAWN: KEK
Structural Geology in the Vicinity of the Sunnyside Mine, San Juan County, Co.	CHECKED:
	APPROVED:
	DWG NO:
	PROJ.: 464110361
Hydro-Search, Inc. HYDROLOGISTS-GEOLOGISTS-ENGINEERS	Figure 4

Rock alteration and mineralization is widespread in the vicinity of the San Juan caldera. "Propylitic alteration has affected many cubic miles of volcanic rocks throughout and beyond the [Silverton] caldera" (Burbank, 1960). In the propylitized rocks "pyrite is ubiquitous and forms between 0.1 and 2.0 percent" of the rock volume (Casadevall and Ohmoto, 1977, p. 1292). In excess of one billion tons of pyrite are estimated to exist in rocks in the vicinity of the Sunnyside Mine (assuming 5 cubic miles of propylitized rocks with 1.0% pyrite). The weathering of this dispersed pyrite as well as other mineralization has resulted in the pervasive staining which is common in rocks throughout the area (e.g. Red Mountains 1, 2, and 3).

3.2 Bedrock Permeability

Fracture permeability in the vicinity of the Sunnyside Mine is anisotropic. Permeability is greater in a northeast/southwest direction due to the dominant fracture orientation within the Eureka graben. In addition, fracture permeability is greater in the welded tuffs and flows than in the unwelded units. The southwest dip in the vicinity of the mine results in zones of greater permeability which dip southwest along the more highly fractured units. The overall effect is that the greatest permeability zones trend northeast/southwest and dip about 10° - 14° southwest. Field evidence for this anisotropy in permeability includes a preferred orientation for ore shoots. Figure 5 shows an example of a northeast/southwest trending ore shoot which dips southwest.

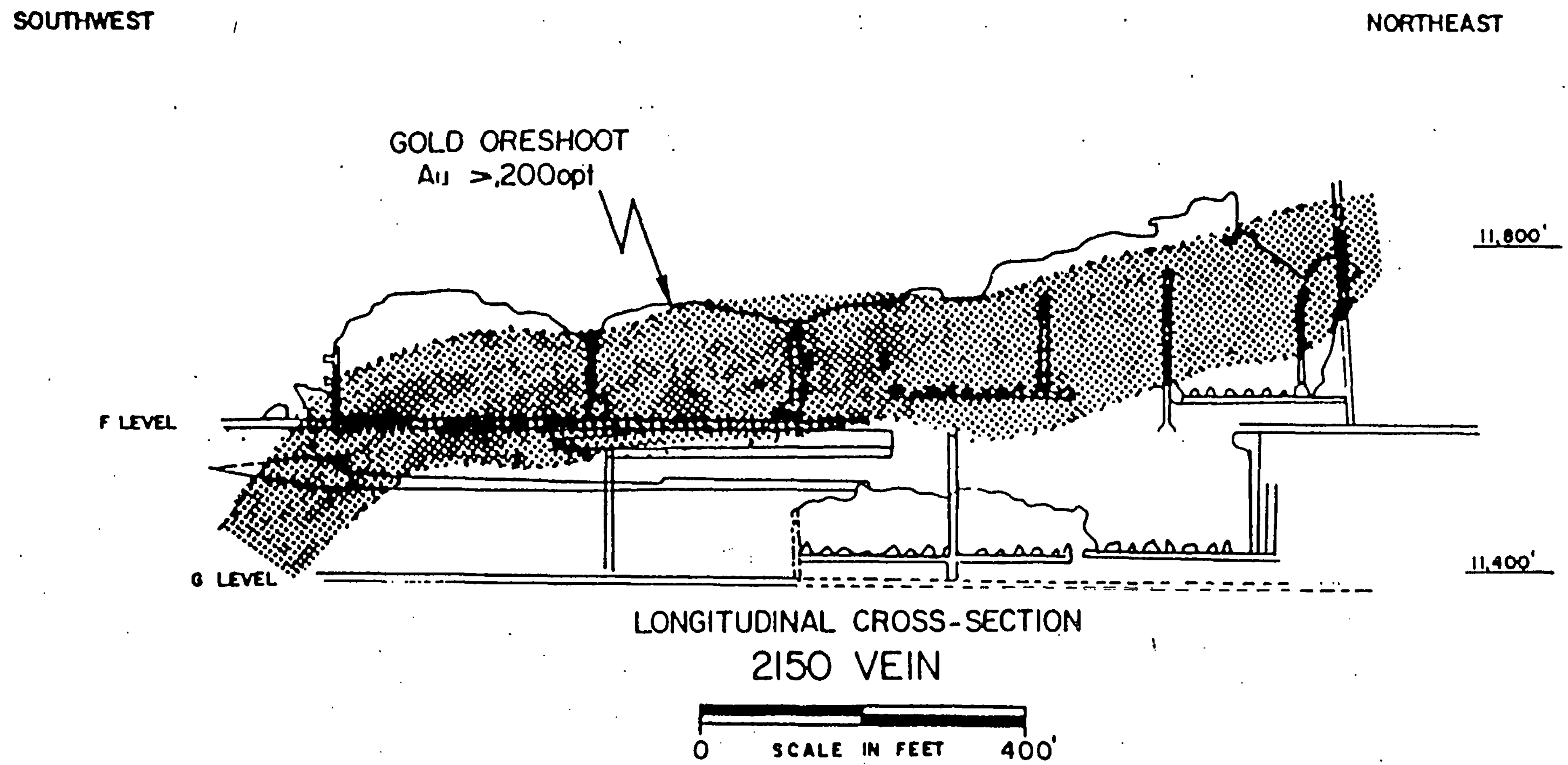


Figure from Sunnyside Gold

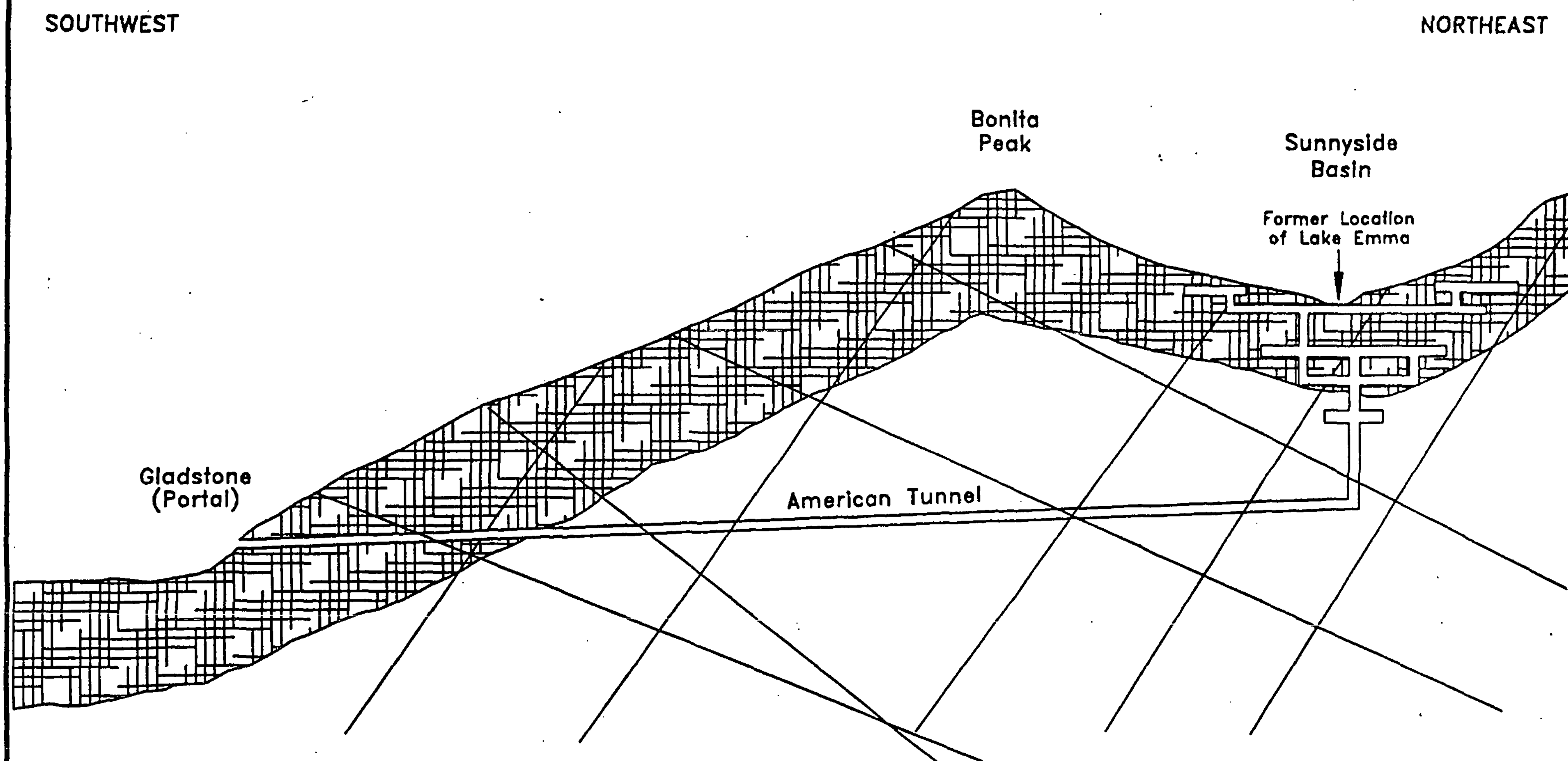
San Juan County Mining Venture Silverton, Colorado	DATE: 10/21/91 DRAWN: KEK
A Southwest Raking Ore Shoot on the 2150 Vein Sunnyside Mine	CHECKED: APPROVED: DWG NO: PROJ.: 464110361
Hydro-Search, Inc. HYDROLOGISTS–GEOLOGISTS–ENGINEERS	Figure 5

Fracture permeability generally decreases with depth as the fractures are made progressively tighter by increasing overburden pressure. Evidence for this can be observed in both the American Tunnel and the Terry Tunnel. At locations deep within the mine, water enters each tunnel only where major fractures are encountered, and most of the back and rib of the tunnel is dry. However, as the portals are approached decreasing overburden pressure allows relatively minor joints to transmit water and dripping water becomes common.

In the deeper parts of the flow system, significant quantities of water are transmitted only by major fractures. This is demonstrated by the fact that the deeper part of the present American Tunnel (beyond the Daylight Corner at approximately 2700 feet from the outside end of track[1]) has intercepted 1350 gpm of ground water. Of this 1350 gpm, 90 percent can be accounted for from the intersection of five major fracture zones (the Washington vein, the Sunnyside vein, the Brenneman vein, a fracture zone at the 0700 runaround, and a fracture zone located 3020 to 3220 feet from the end of track (see section 4.2.1). Figure 6 is a schematic diagram showing the manner in which fracture permeability changes with depth.

---

[1] All footages along the American Tunnel are referenced to track repair footages as marked on the tunnel wall. The track repair footages have a zero point just outside of the portal.



EXPLANATION

Zone where minor fractures transmit significant quantities of water.

Major fractures which transmit water even under considerable overburden pressure.

Mine workings.

NOT TO SCALE

San Juan County Mining Venture Silverton, Colorado	DATE: 10/23/91
	DRAWN: DRD
Schematic of Differing Fracture Permeability With Depth	CHECKED:
	APPROVED:
	DWG NO:
	PROJ.: 464110361
Hydro-Search, Inc. HYDROLOGISTS-GEOLOGISTS-ENGINEERS	Figure 6

3.3 *Pre-Mining Potentiometric Surface*

Simon Hydro-Search has used observations from 1959 and 1961 to estimate the equilibrium static water level beneath the Sunnyside Basin. Mr. Bob Ward (mine superintendent during construction of the American Tunnel) personally saw that the static water level in the Washington Inclined Shaft was approximately 50 feet below F level during the summer of 1959. Mr. Ward's recollection appears reasonable in light of a letter from D. Hutchinson to Messrs. William R. McCormick and Robert M. Hurst dated February 3, 1961. This letter states that during January of 1961 (after the American Tunnel had intersected some of the fractures under the old workings) "the water was 97 feet below F level and falling 3½ feet per day". The observed water levels in 1959 and 1961 were below F level where drainage to the surface would have occurred via the Terry Tunnel. The 1959 static water level reflects a lack of dewatering during the preceding 20-year period during which time the mine was inactive. The 1959 static water level is thought to represent an equilibrium condition of inflow to the workings versus outflow via natural fracture permeability. It is worth noting that this static water level is deep enough that most of the minor joints would be closed by the overburden pressure.

Direct surface-water inflow to the mine in 1959 was far less than in 1992. Hence, the static water level in 1959, estimated at 11,500 feet above mean sea level (msl), is assumed to approximate the static water level in the fractured bedrock prior to commencing mining.

Lake Emma was a glacial tarn in Sunnyside Basin at an elevation of approximately 12,250 feet msl. On June 4, 1978 Lake Emma drained into workings on the Spur vein causing massive damage throughout the mine (Bird, 1986, p. 135). In areas of high permeability a lake can usually be considered to represent the water table. However, this does not appear to have been the case for Lake Emma. Two samples of the lacustrine clays which formerly were under Lake Emma were tested in August 1988 and shown to have permeabilities ranging from 1.6×10^{-7} to 6.7×10^{-9} cm/sec under 95% relative compaction. These permeability values are very low and little water would have been transmitted through such material. Lake Emma is considered to have been perched on low permeability lacustrine clays.

3.4 Pre-Mining Direction of Ground-Water Flow

Prior to the existence of the mine, the gradient was approximately 0.1 feet/foot from the head of Sunnyside Basin to either Cement Creek, at Gladstone, or to the Animas River at the site of Eureka (see Table 1). If the pre-mine hydraulic head under Sunnyside Basin had been higher or lower the hydraulic gradient would have a different value, but the rate of change in gradient would be about the same to the southeast (toward Midway Mill site) as to the southwest (toward Gladstone).

Table 1. Estimated Pre-Mine Ground-Water Gradient within the Fractured Bedrock			
	Elevation[1] (feet msl)	Distance[1] from Workings under Sunnyside Basin (feet)	Gradient[2] from head of Sunnyside Basin to indicated point
Cement Creek near Portal of American Tunnel	10,500	9,500	0.105
Discharge Zone near Mogul Mine Portal	11,250	6,300	0.040
Animas River at Site of Eureka	9,850	15,600	0.106
Eureka Gulch near Midway Mill Site	10,480	9,300	0.110

1) Estimated from U.S.G.S. Handies Peak and Ironton 7 1/2 minute quadrangles

2) Assumes the pre-mine hydraulic head in the fractured bedrock beneath Lake Emma was approximately 11,500 feet above mean sea level (based on the 1959 water-level observation of Mr. Bob Ward).

If permeability had been homogeneous and isotropic, the groundwater would have moved in both directions. However, a strong anisotropy exists with enhanced permeability both in a northeast/southwest direction and also dipping southwest. In addition, greater fracture permeability associated with a higher degree of welding of the volcanics is expected beneath the Gladstone area than beneath the Sunnyside basin. The local anisotropy and inhomogeneity of the fracture permeability would facilitate ground-water movement toward Cement Creek. Hence, the majority of water in the bedrock flow system is inferred to have moved from the Sunnyside Basin to the Cement Creek drainage where it discharged as springs and seeps.

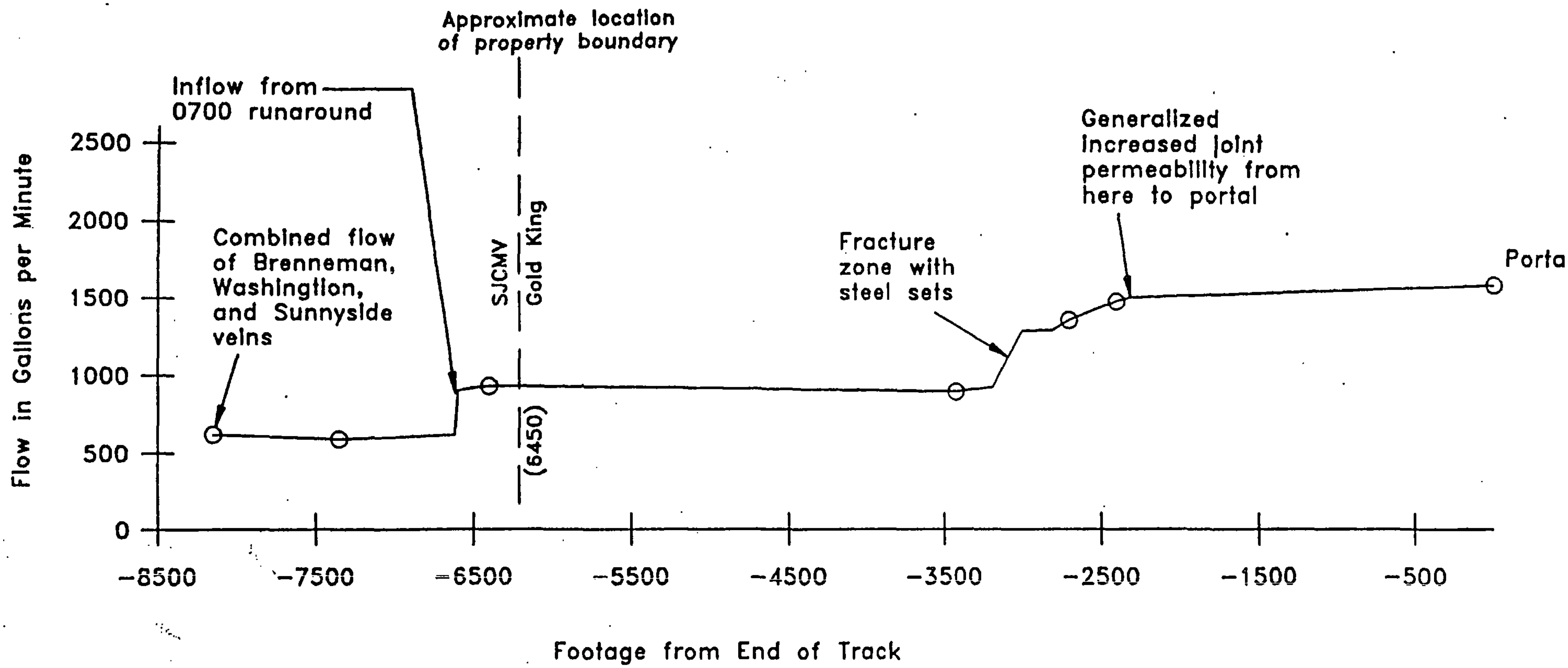
Field evidence supports the idea that the preferred ground-water flow direction is southwest rather than southeast in the vicinity of the Sunnyside Mine. Field observations by Simon Hydro-Search staff during July and August, 1991 located a greater number of visible springs and seeps in the Cement Creek drainage, above Gladstone, than in Eureka Gulch. Furthermore, the springs and seeps in the two forks of Cement Creek above Gladstone are preferentially located on the east side of the creek, indicating a source to the east is most likely. Finally, based on the volume of dumps, the Silver Ledge Mine, located on the east side of the South Fork of Cement Creek, appears to have approximately the same extent of underground workings as the Big Colorado Mine located directly across the creek. Yet, based on the present flow from the portals, the Silver Ledge Mine intercepted approximately ten times as much water as the Big Colorado Mine.

4.0 HYDROLOGY AFTER PROPOSED BULKHEADS ARE INSTALLED

This section outlines the overall hydrologic situation which is expected to result from the installation of underground bulkheads proposed by SGC. Many of the details and supporting evidence for this conceptual hydrologic model are provided in the following sections.

Once the bulkhead is installed in the American Tunnel (near the underground property line with the Gold King Mine) waters presently leaving the Sunnyside Gold property are expected to be impounded behind the bulkhead. The physical and chemical integrity of the bulkhead itself are considered in a separate report by Abel, 1993. The rate of localized leakage around the bulkhead is considered in Section 7.3 of this report.

It should be noted that the proposed bulkhead near the underground property line is expected to impound the water which originates on SGC property, but a significant amount of water originating on Gold King property will not be impounded. Figure 7 shows that approximately 930 gpm presently flows past the proposed American Tunnel bulkhead site, but that approximately an additional 650 gpm flows into the American Tunnel from Gold King property. Hence, the American Tunnel portal is expected to flow an average of approximately 650 gpm even after installation of the proposed bulkhead. The rate of flow downstream of the proposed American Tunnel



EXPLANATION

O Flow Measurement Points

NOTES

1. Footages are distance from end of track as marked on the wall of the American Tunnel and are approximate. The end of track is just outside of the American Tunnel portal.

2. Flow at all points except portal was measured with a pygmy flow meter by Evelyn Bingham and Guy Lewis of SJCMV on October 2–3, 1991. Portal flow represents an average of flume measurements.

/usr4/san-juan/acad/464ch012.DWG

San Juan County Mining Venture Silverton, Colorado	DATE: 03/08/93
Flow Profile Along the American Tunnel	DESIGNED:
	CHECKED:
	APPROVED:
	DRAWN: RAS
	PROJ.: 464110361
SIMON HYDRO-SEARCH	**Figure 7**

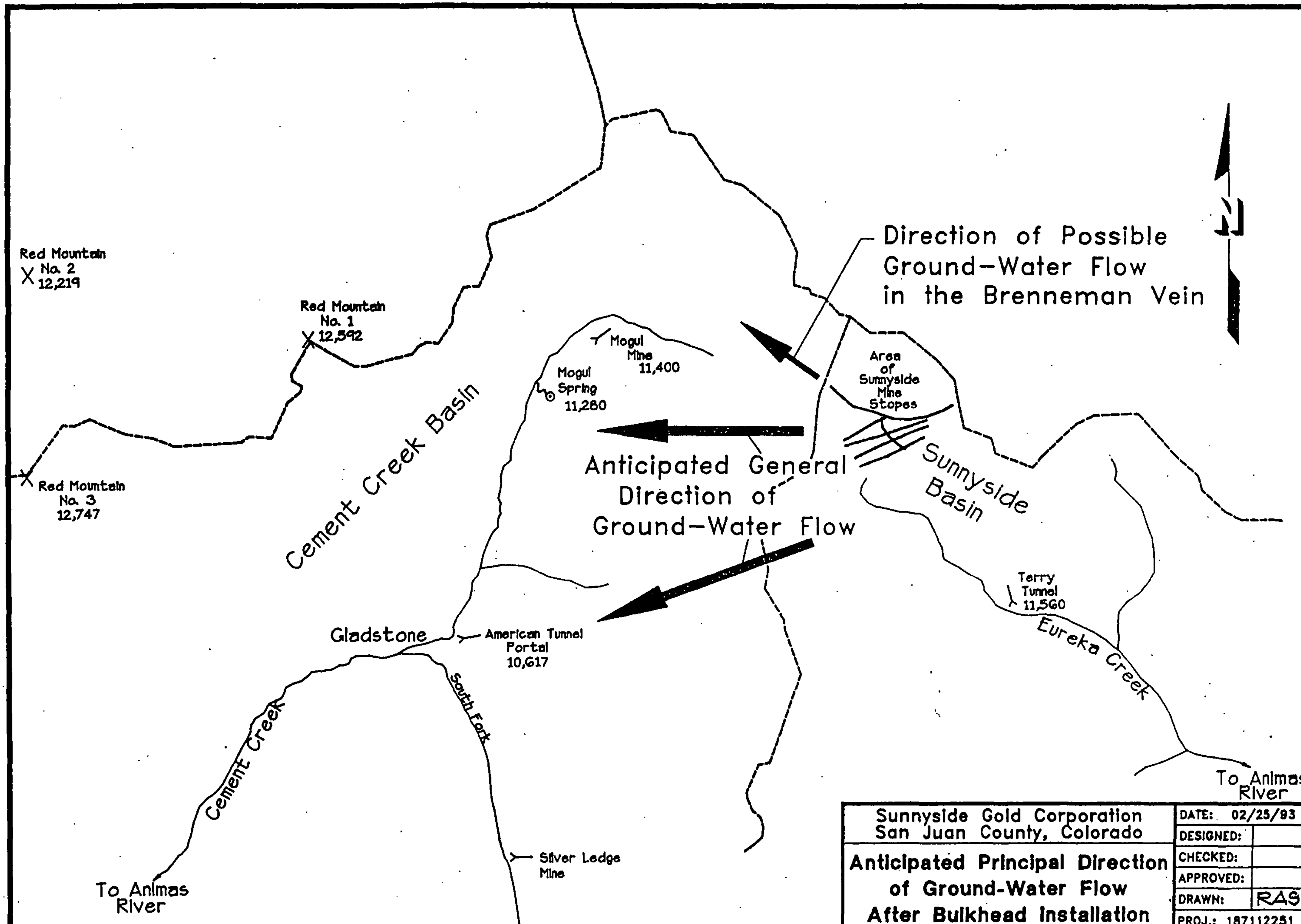
bulkhead site is not expected to increase substantially after bulkhead construction because no significantly permeable fractures have been observed for the next 3000 feet downstream.

The Sunnyside Mine workings are expected to fill with water until an equilibrium is reached between water flowing into the mine workings and water leaving the mine workings via natural fracture pathways. If the ongoing reclamation work in Sunnyside Basin is successful in diverting surface water from entering underground workings, then the equilibrium water level in the flooded mine workings is expected to be just below F-level at approximately 11,500 feet msl (see Sections 3.3 and 7.1 for details). If surface water inflow to the mine is not substantially decreased, then the equilibrium water level may be correspondingly higher. The absolute maximum possible equilibrium water level is at the elevation of land surface in the Sunnyside Basin (approximately 12,250 feet msl).

Although equilibrium water level in the flooded workings is expected to be just below F-level, three additional bulkhead locations have been proposed by SGC to impound water in case it rises as high as the land surface in Sunnyside Basin. A proposed bulkhead in the Terry Tunnel is intended to keep water from flowing out of the Terry Tunnel portal. Two sets of proposed bulkheads on the Brenneman vein, one set on F-level and one set on B-level (at approximately 12,150 feet) are intended to keep water from flowing into the Mogul Mine. Although only one tunnel connects the

Sunnyside and Mogul mines (at an elevation of 11,904 feet msl), access to that tunnel is so difficult that it is more convenient to place two sets of bulkheads at locations before the workings converge to a single tunnel. There also exists a connection between the Sunnyside Mine and the Gold Prince Mine (with a portal in Placer Gulch), but the connection is at least 150 feet higher than land surface in the Sunnyside Basin.

Once an equilibrium water level is established in the flooded mine workings (and perhaps even earlier) some water is expected to move along natural fracture pathways from the flooded mine workings toward the Cement Creek Basin. The natural pre-mining ground-water flow directions (discussed in Section 3.4) are expected to be reestablished. The majority of the ground-water flow is expected to be toward the west and southwest as indicated on Figure 8. Most of the permeable fractures are oriented southwest, but the Brenneman vein also appears to be somewhat permeable and is oriented west-northwest. The estimated rate of ground-water flow through the flooded mine workings is discussed in Section 8.2 and the transit time from the mine workings to the surface is considered in Section 8.3.



Note: Locations of stopes in Sunnyside Basin are generalized.

Sunnyside Gold Corporation San Juan County, Colorado	DATE: 02/25/93
	DESIGNED:
Anticipated Principal Direction of Ground-Water Flow After Bulkhead Installation	CHECKED:
	APPROVED:
	DRAWN: RAS
	PROJ.: 187112251
SIMON HYDRO-SEARCH	**Figure 8**

5.0 ESTIMATION OF HYDRAULIC HEAD AND HYDRAULIC CONDUCTIVITY FROM FLOW TESTS

The average hydraulic conductivity of the fractured volcanic rocks near the 0700 and 1500 runarounds in the American Tunnel is estimated to be on the order of $5x10^{-5}$ cm/sec (0.15 feet/day). These conclusions are based on an analysis of flow tests described in detail in the remainder of this section. Rock in the vicinity of the flow tests may be somewhat more permeable than is typical for the deep rocks in the vicinity of the Sunnyside Mine.

Constant discharge flow tests were conducted on December 17 and 18, 1992, from two longholes (diamond drill holes) located in the American Tunnel. The purpose of these tests was to estimate the present hydraulic head over the American Tunnel and to estimate the average hydraulic conductivity of the fractured volcanic rocks in the vicinity of the tests. The analytical techniques applied to the test results can only produce rough averages over the entire length of open borehole.

5.1 Description of the Drill Holes Used for Flow Testing

In the Terry Tunnel (F-level) a diamond drill hole was drilled in late 1992 for the purpose of estimating hydraulic parameters. The hole was drilled east-northeast from the general vicinity of one of the bulkhead sites proposed by SGC. As expected, the hole did not encounter water and no flow testing was conducted.

In the American Tunnel three longholes (700, 702 and 704) were collared at the 1500 Runaround on the southeast rib and drilled to the southeast at different angles. The longholes were originally drilled for mineral exploration objectives, not for estimating hydraulic parameters. Hole 700 was drilled at an upward angle of ½ degree; hole 702 was drilled at an upward angle of 10 degrees; and hole 704 was drilled at a downward angle of 10 degrees. "Downhole" surveys were not conducted in any of these longholes. All three holes were grouted at the collar and fitted with shut-off valves and pressure gauges in preparation for the flow tests. Two longholes (781 and 778) were located at the 0700 Runaround. Hole 781 was drilled into the southeast rib at an upward angle of 17 degrees, but was not surveyed. Hole 778 was drilled into the northwest rib at a bearing to the north-northeast. Continuous downhole surveys show the hole started at an upward angle of 9 degrees and finished at an upward angle of 24 degrees.

5.2 Flow Test Methodology

The first flow test was conducted from hole 700 at a constant discharge of 135 gallons per minute (gpm). A Water Specialties Corporation model ML-04 flowmeter was used to measure discharge and Ashcroft 300 psi gauges were used to measure water pressures in the discharge line from hole 700 and at the collars of holes 702 and 704. Holes 781 and 778 at the 0700 Runaround were checked during the test; however, neither hole responded to the first test. The flow test was conducted for four hours and five minutes (245 minutes). Recovery was monitored in holes 700 and 704 for 90 minutes after hole 700 was shut in.

The second flow test was conducted from hole 781 at a constant discharge of approximately 48.5 gpm. The test lasted four hours (240 minutes) and recovery was monitored for 90 minutes. The longholes at the 1500 Runaround were not monitored during the second test.

5.3 Measurement of Hydraulic Head

No water was encountered in the drill hole in the Terry Tunnel (F-level). However, circulation was lost into an open fracture at one point indicating that there is some fracture permeability. The lack of water in the presence of fracture permeability proves that the fractured rocks surrounding the Terry Tunnel (nominal elevation 11,562 feet msl) are not presently saturated. Unsaturated rocks were expected at F-level based on the apparent equilibrium water levels observed in 1959 - 1961 (Section 3.0).

Water flows from all drill holes in the vicinity of the 0700 and 1500 runarounds in the American Tunnel (nominal elevation 10,668). This indicates that the American Tunnel is below the water table. The permeability of the volcanic rocks is generally so low that water only enters the tunnel in a few permeable fractures.

Table 2. Hydraulic Head Measured in Boreholes in the American Tunnel					
Hole Number	Length (feet)	Angle from Horizontal (degrees)	Estimated Elevation Change Along Hole (feet)	Static Head (psi)	Static Head Above American Tunnel Level (feet)
700	2022	+ 1/2	+ 18	132	304
702	1012	+ 10	+ 176	79	182
704		- 10	—	129	298
781	660	+ 17	+ 193	132	304

The static hydraulic heads measured in the drill holes are given in Table 2. The measured hydraulic heads represent mix of heads over the length of the boreholes and it is not possible to precisely relate the hydraulic head to distance from the American Tunnel. However, it is clear that the hydraulic head in the vicinity of the tests is generally approximately 300 feet higher than the American Tunnel.

The area of the test is relatively highly fractured and serves to drain water from the fractured bedrock into the mine. Hence, the measured hydraulic heads do not represent the static equilibrium that would exist without the mine workings, but, rather, a cone of depression induced by the presence of the mine.

5.4 Estimate of Hydraulic Conductivity

Both log-log and semi-log plots of the rate of pressure change with time during the flow periods for holes 700, 702, and 704 (first test) and hole 781 (second test) are given in Appendix A. Semi-log recovery plots of pressure build-up versus t/t' (time since flow began divided by the time since flow was terminated) also are included. The drawdown plots for the first test do not provide for simple analysis by the Theis or Cooper-Jacob (1946) methods. This is probably due to turbulent flow within the small-diameter, uncased longhole (hole 700) and boundary effects along the highly transmissive fractures. Hole 700 drawdown data shows a more atypical plot than the drawdown data from holes 702 and 704.

However, the semi-log plots of the recovery data from both 700 and 704 produced straight lines. The calculated "transmissivities" from the recovery plots for 700 and 704 are 2,000 gallons per day per foot (gpd/ft) and 1,300 gpd/ft, respectively (Table 3). Due to the nature of the testing these calculated values should not be considered true transmissivities. Rather, the calculated value is a function of the average hydraulic conductivity and the length of the hole. The calculated hydraulic conductivities range from 0.1 to 0.2 ft/day. The calculated hydraulic conductivities are expected to be of the correct order of magnitude.

Both the semi-log drawdown and recovery plots for the second test (hole 781) produced straight lines. The calculated hydraulic conductivities are on the order of 0.2 ft/day.

The geometric mean of the calculated hydraulic conductivities is 0.15 ft/day. However, the rock in the vicinity of the flow tests exhibits more fracture permeability than is typical for the American Tunnel. Therefore, this calculated hydraulic conductivity is expected to be considerably higher than the general average for fractured rocks in the area.

Table 3. Hydraulic Conductivities Estimated from Flow Tests in the American Tunnel

Hole	Calculated "Transmissivity" Early Time gpd/ft	Calculated "Transmissivity" Late Time gpd/ft	Data Type	Length	Estimated Hydraulic Conductivity ft/day	Hydraulic Conductivity cm/sec
700	2,000	1,325	Recovery Test	2022	0.1 3/0.09	$4.6x10^{-5}$/ $3.2x10^{-5}$
704	1,300		Recovery Test	1012	0.17	$6.0x10^{-5}$
781	980		Drawdown Test	660	0.20	$7.0x10^{-5}$
781	930		Recovery Test	660	0.19	$6.6x10^{-5}$
Geometric Mean					0.15	$5.3x10^{-5}$

6.0 RATE OF FLOODING OF MINE WORKINGS

The rate at which the underground workings will fill with water after installation of the proposed bulkheads depends upon the volume of mine workings, at the rate of inflow of water to the mine workings, and the porosity of the surrounding fractured volcanic rocks. Two methods of estimating the schedule of mine flooding predict that the water level will substantially reach equilibrium (86% of equilibrium) in a range of between one and ten years.

6.1 Estimate Using Volume of Workings and Constant Flow

SGC staff used detailed maps and sections of the underground workings of the Sunnyside Mine to calculate the volume of mine workings in increments of 100 vertical feet. Sections along stopes and tunnels were planimetered and compared to widths on plan views or to measured stope widths. The resulting mine volume data are summarized in Table 4. A more detailed volumetric analysis may be found in Appendix B.

One method of estimating the schedule at which the mine workings will fill with water is to assume that the volume of water entering the mine workings will remain constant until an equilibrium water level is reached. Table 4 shows the schedule of flooding using this method. The estimated time to flood the mine to the anticipated equilibrium water level of 11,500 feet msl using 930 gpm (the present flow rate at

Table 4. Volume of Sunnyside Workings by Level and Calculated Time to Flood Workings				
Vein Section	Total Cum. cu.ft.	Total Cum. Gal.	Days 930 gpm	Days 1230 gpm
10700	1431680	10710462	8	6
10800	4235240	31679595	24	18
10900	7295720	54571906	41	31
11000	9369288	70082274	52	40
11100	10834208	81039876	61	46
11200	11950003	89386060	67	50
11300	14378852	107553813	80	61
11400	18289228	136803425	102	77
11500	26120289	195379762	146	110
11600	34284871	256450835	191	145
11700	45373477	339393608	253	192
11800	53433594	399683283	298	226
11900	59985360	448690493	335	253
12000	64385568	481604049	360	272
12100	67889040	507810019	379	287
12200	70358352	526280473	393	297

Note: Calculation assumes inflow rate is constant and surrounding rock has no porosity the proposed American Tunnel bulkhead site) is 146 days. Assuming a constant inflow rate of 1230 gpm (the American Tunnel flow rate plus slightly more than the historical average flow from the Terry Tunnel) yields 110 days. In actuality, the rate of inflow will decrease as the water level rises in the flooding workings. In a more conservative case, the time required to completely flood the mine workings would be slightly over two years if the average inflow rate is half of the present American Tunnel flow rate, and that the equilibrium water level is actually at the surface in Sunnyside Basin.

6.2 Estimate Using a Ground-Water Flow Model

The estimated schedules of the flooding of mine workings discussed in section 6.1 do not consider changes in inflow rate with time, nor porosity of the fractured volcanic rocks. To overcome these simplifications a numerical ground-water flow model was developed. The U.S. Geological Survey MODFLOW code was employed to create a simple model of the mine drainage via the American Tunnel.

The model employed a number of simplifying assumptions including

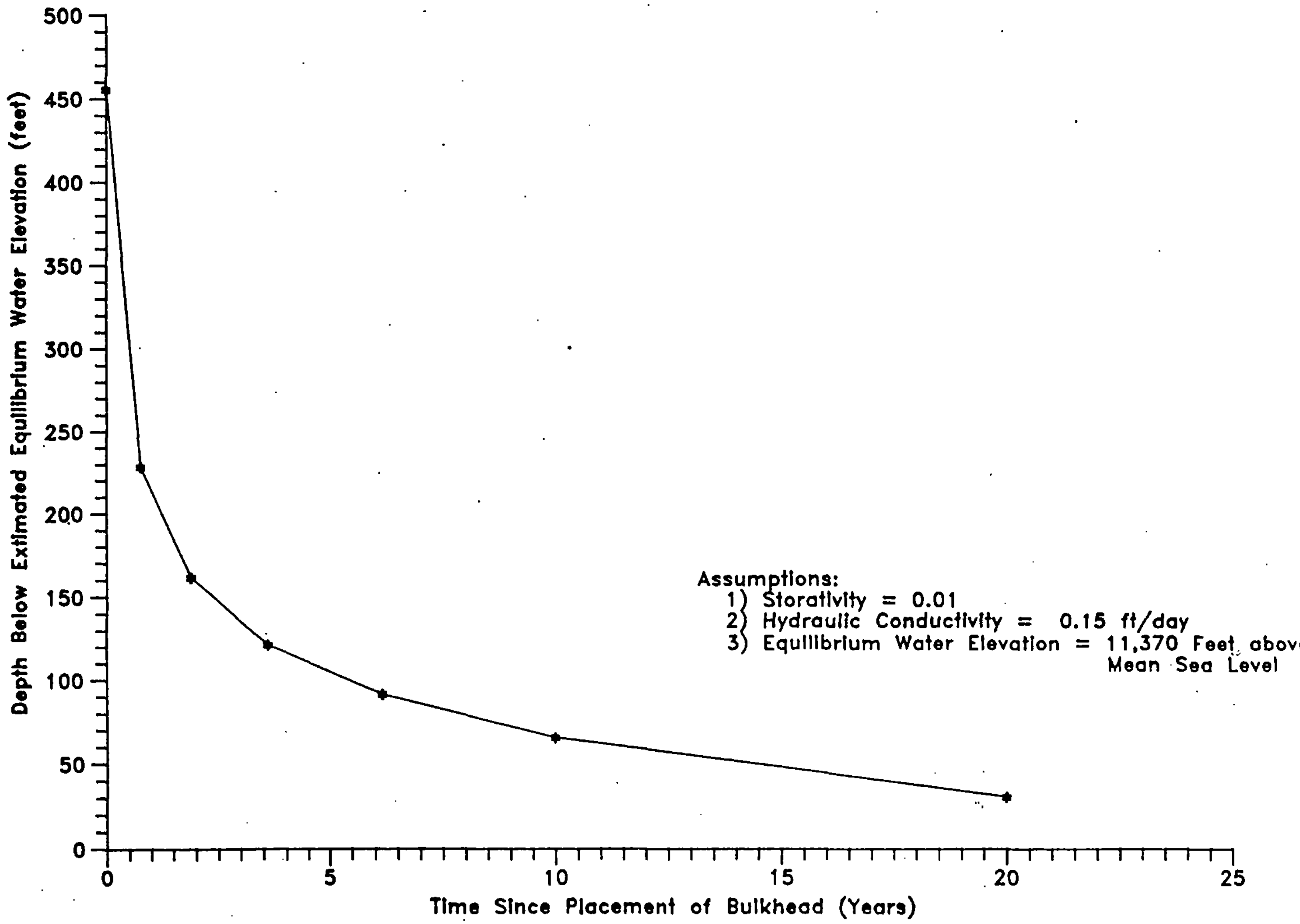
- initial hydraulic head prior to mine dewatering is constant at an elevation of 11,370 feet msl,
- hydraulic conductivity is constant at 0.15 ft/day (the geometric mean of the results of flow testing in the American Tunnel),
- the fractured volcanic rocks are only permeable down to an elevation of 9668 feet msl (1000 feet below the American Tunnel Level),
- the storativity is constant at 0.01,
- there is no recharge from above or below, and
- all inflow to the mine is from constant head boundaries at a distance of over four miles from the mine workings.

This is assum which Dar "best cas

Although the initial hydraulic head employed in the model is somewhat lower than the expected equilibrium water level, the estimated drawdown and recovery rates would not be significantly affected by the difference. In spite of the simplifying assumptions, the model is useful for obtaining a rough approximation of the flooding schedule.

The American Tunnel began draining the Sunnyside Mine in early 1961 (approximately 33 years prior to estimated bulkhead construction). During modeling the mine was allowed to dewater the surrounding fractured rocks for a modeled time interval of 33 years via a drain at the American Tunnel Level. The drain in the model was calibrated so that the average discharge from the drain was 899 gpm (compared to a present discharge of approximately 930 gpm). The model predicted head after 33 years of draining also corresponds well to the observed heads near the 0700 and 1500 runarounds (Section 5.3). After the 33 years of dewatering the drain was "plugged" to simulate bulkhead construction. The model-estimated rate of mine flooding is shown on Figure 9. The mine is modeled as being 86% filled with water in 10 years.

Reasonable estimates of hydraulic parameters were employed in the model. If the actual average porosity is greater than the modeled value (0.01) the mine will refill somewhat more slowly than modeled. If the actual average hydraulic conductivity is less than the modeled hydraulic conductivity (0.15 ft/day) then the mine will also refill somewhat more slowly than modeled. These effects should be more than offset by



Sunnyside Gold Corporation
San Juan County, Colorado

Schedule of Mine Flooding Based on MODFLOW Model

DATE: 03/08/93	
DESIGNED:	RGB
CHECKED:	
APPROVED:	
DRAWN:	RAS
PROJ.: 187112251	

SIMON

Figure 9

the fact that there will be some recharge from the surface which will probably be roughly equivalent to the annual average discharge from the Terry Tunnel. In 1992 the average Terry Tunnel discharge was approximately 215 gpm, but it is expected to be less than 100 gpm after completion of surface water diversions in the Sunnyside Basin.

7.0 RATE OF LEAKAGE AROUND BULKHEADS

does this include Brennan

The rate of leakage through the bedrock in the immediate vicinity of each proposed bulkhead is expected to be less than 25 gallons per minute. Support for this estimate is detailed in the remainder of this section. The bulkhead design by Dr. John Abel (see "Bulkhead Design for the Sunnyside Mine: Sunnyside Gold Corp., An Echo Bay Company", 1993) is intended to minimize the amount of leakage through the bulkhead itself, and at the contact between the bulkhead and the bedrock. The anticipated overall rate of ground-water flow from the flooded mine workings to Cement Creek is discussed in Section 8.2.

7.1 Equilibrium Water Level Behind the Bulkheads

The water level behind the proposed bulkheads is expected to rise until the rate of outflow from the flooded mine workings is equal to the rate of inflow from the ground water system and openings in Sunnyside Basin. The outflow will be via natural (fracture) pathways because all possible man-made pathways will be blocked by bulkheads all the way up to the level of the surface in Sunnyside Basin.

The equilibrium water level in the flooded mine workings is anticipated to be just below F level (approximately 11,500 feet msl). This is based on historical observations of water levels in the Sunnyside Mine after 20 years of inactivity (Simon Hydro-Search, 1992, pp. 18-19).

Direct surface-water inflow to the mine was less during the aforementioned observations (1959-1961) than during recent years. The increase in surface-water inflow in recent years has resulted from the opening of the Lake Emma Hole and auto-stoping of other mine workings to the surface (Simon Hydro-Search, 1992, pp. 35-36). However, ongoing reclamation work in Sunnyside Basin has filled the Lake Emma Hole, and blocked or diverted many of the other sources of surface water. How effect?

If the amount of surface water inflow continues to be greater than during the 1959-1961 observations, then the equilibrium water level may be correspondingly higher. Therefore, leakage analyses contained in later sections of this report contain estimates based on both expected equilibrium water lever (near F level), and a most conservative case (surface level in Sunnyside Basin).

7.2 Permeability at Proposed Bulkhead Sites

Cores were taken of the wall rock at each of the proposed bulkhead sites (American Tunnel, Terry Tunnel, F-Level Brenneman and B-Level Brenneman). These cores were submitted to Petroleum Testing Service, Inc. of California for laboratory measurement of permeability to water. Permeability was measured using EPA Method 9100 with a 250 psi net confining stress at 74°F.

Hydraulic conductivities ranged from 10^{-8} to 10^{-10} cm/sec for unfractured core, to 10^{-6} cm/sec for core showing fractures. Results are summarized in Table 5. The

Table 5. Permeabilities Based on Laboratory Testing of Rock Cores

Sample I.D.	Water Permeability Test 250 psi Net Confining Stress at 74°F	
	Effective Permeability milldarcy	Hydraulic Conductivity cm/s
B-Level Nth Rib	0.002	2.08×10^{-9}
B-Level Sth Rib	0.002	2.08×10^{-9}
Brenneman Back	0.001	5.31×10^{-10}
Brenneman Nth Rib	0.006	6.25×10^{-9}
Brenneman Sth Rib	0.001	6.35×10^{-10}
Terry Tunnel Back **	4.27	4.44×10^{-6}
Terry Tunnel Nth Rib	0.002	2.08×10^{-9}
Terry Tunnel Sth Rib	0.002	2.08×10^{-9}
American Tunnel Back	0.013	1.35×10^{-8}
American Tunnel Nth Rib	0.001	1.04×10^{-9}
American Tunnel Sth Rib **	9.27	9.66×10^{-6}

** Fractured sample
* EPA Method 9100

extremely low hydraulic conductivities were expected in the unfractured volcanic rocks (Freeze and Cherry, 1979, p.29).

The fractured core is thought to be the result of rock damage caused by blasting during construction of the underground workings. Such blast damage is limited to the immediate vicinity of the mine workings, typically extending no more than 5 feet (Worsey, 1985; Worsey, 1986; and Siskind and Fumati, 1974). Hence, a damaged rim a few feet thick around the tunnels is expected to have an artificially induced permeability of 10^{-6} cm/sec.

Flow testing of boreholes in the American Tunnel resulted in an overall hydraulic conductivity of $5x10^{-5}$ cm/sec when averaged from boreholes oriented perpendicular to the general orientation of the fracture system (see Section 4.0). The hydraulic conductivity of $5x10^{-5}$ cm/sec results from a relative few, widely-spaced fractures. The proposed bulkhead sites were selected in areas where no major fractures were observed. Hence, for the purpose of calculating leakage in the immediate vicinity of the proposed bulkheads a value of $5x10^{-5}$ cm/sec is probably too high.

7.3 Leakage in the Immediate Vicinity of the Bulkheads

Darcy's equation was used to estimate the rate of leakage through the fractured volcanics in the immediate vicinity of the proposed bulkheads. Darcy's equation is:

$$Q = KIA \quad \text{where:}$$

Q = discharge (i.e. leakage)
K = hydraulic conductivity
I = gradient, and
A = the cross-sectional area of the "aquifer" through which water flows.

A spreadsheet (Table 6) was developed in order to allow a range values of hydraulic conductivity, gradient, and area. The expected values correspond to a hydraulic conductivity of 10^{-6} cm/sec, a hydraulic head near F-Level, and a blast damage zone out to 3 feet from the mine walls. The leakage through the fractured volcanics is expected to be less than 0.1 gallon per minute (Case B on Table 6). Conservative values correspond to a hydraulic conductivity of 5×10^{-5} cm/sec and a hydraulic head at the level of the land surface in Sunnyside Basin. The leakage via the fractured volcanics in the conservative case is still less than 25 gallons per minute at any given bulkhead (Case I on Table 6).

Table 6. Sunnyside Mine Ground–Water Flow Around Bulkhead Calculation Sheet

Performed by Bob Butler 12/24/92 revised 12/28/92

CASE A

Adit (name)	Permeability (cm/sec)	Permeability (ft/day)	Adit Elevation (feet)	Length of Plug (feet)	Hydraulic Gradient (feet/foot)	Cross Sectional Plug Area (feet²)	Cross Sectional Flow & Plug Area (feet²)	Cross Sectional Flow Area (feet²)	Calculated Flow (gpm)	Calculated Flow (gpd)
Brenneman B	1.00E–06	2.83E–03	12122	3	42.67	100	256	156	0.10	141
Brenneman F	1.00E–06	2.83E–03	11562	8	86.00	100	256	156	0.20	284
Terry F	1.00E–06	2.83E–03	11562	8	86.00	144	324	180	0.23	328
American	1.00E–06	2.83E–03	10668	25	63.28	169	361	192	0.18	258

Note: Assumes Static Head Elevation of 12250 (Lake Emma) and 3 foot fracture distance from each side of the plug.

CASE B

Adit (name)	Permeability (cm/sec)	Permeability (ft/day)	Adit Elevation (feet)	Length of Plug (feet)	Hydraulic Gradient (feet/foot)	Cross Sectional Plug Area (feet²)	Cross Sectional Flow & Plug Area (feet²)	Cross Sectional Flow Area (feet²)	Calculated Flow (gpm)	Calculated Flow (gpd)
Brenneman B	1.00E–06	2.83E–03	12122	3	*	100	256	156	*	*
Brenneman F	1.00E–06	2.83E–03	11562	8	3.75	100	256	156	0.01	12
Terry F	1.00E–06	2.83E–03	11562	8	3.75	144	324	180	0.01	14
American	1.00E–06	2.83E–03	10668	25	36.96	169	361	192	0.10	150

Note: Assumes Static Head Elevation of 11592 ("F" Level plus 30 foot) and 3 foot fracture distance from each side of the plug.

CASE C

Adit (name)	Permeability (cm/sec)	Permeability (ft/day)	Adit Elevation (feet)	Length of Plug (feet)	Hydraulic Gradient (feet/foot)	Cross Sectional Plug Area (feet²)	Cross Sectional Flow & Plug Area (feet²)	Cross Sectional Flow Area (feet²)	Calculated Flow (gpm)	Calculated Flow (gpd)
Brenneman B	1.00E–10	2.83E–07	12122	3	42.67	100	256	156	0.00001	0.01
Brenneman F	1.00E–10	2.83E–07	11562	8	86.00	100	256	156	0.00002	0.03
Terry F	1.00E–10	2.83E–07	11562	8	86.00	144	324	180	0.00002	0.03
American	1.00E–10	2.83E–07	10668	25	63.28	169	361	192	0.00002	0.03

Note: Assumes Static Head Elevation of 12250 (Lake Emma) and 3 foot fracture distance from each side of the plug.

CASE D

Adit (name)	Permeability (cm/sec)	Permeability (ft/day)	Adit Elevation (feet)	Length of Plug (feet)	Hydraulic Gradient (feet/foot)	Cross Sectional Plug Area (feet²)	Cross Sectional Flow & Plug Area (feet²)	Cross Sectional Flow Area (feet²)	Calculated Flow (gpm)	Calculated Flow (gpd)
Brenneman B	1.00E–10	2.83E–07	12122	3	*	100	256	156	*	*
Brenneman F	1.00E–10	2.83E–07	11562	8	3.75	100	256	156	8.61E–07	0.001
Terry F	1.00E–10	2.83E–07	11562	8	3.75	144	324	180	9.94E–07	0.001
American	1.00E–10	2.83E–07	10668	25	36.96	169	361	192	1.04E–05	0.015

Note: Assumes Static Head Elevation of 11592 ("F" Level plus 30 feet) and 3 foot fracture distance from each side of the plug.

file: G:\SUNNY\LOTUS\PLUGLEAK.WK3

SIMON HYDRO-SEARCH

Table 6. Sunnyside Mine Ground–Water Flow Around Bulkhead Calculation Sheet

Performed by Bob Butler 12/24/92 revised 12/28/92

CASE E

Adit (name)	Permeability (cm/sec)	Permeability (ft/day)	Adit Elevation (feet)	Length of Plug (feet)	Hydraulic Gradient (feet/foot)	Cross Sectional Plug Area ($feet^2$)	Cross Sectional Flow & Plug Area ($feet^2$)	Cross Sectional Flow Area ($feet^2$)	Calculated Flow (gpm)	Calculated Flow (gpd)
Brenneman B	1.00E−06	2.83E−03	12122	3	42.67	100	400	300	0.19	271
Brenneman F	1.00E−06	2.83E−03	11562	8	86.00	100	400	300	0.38	547
Terry F	1.00E−06	2.83E−03	11562	8	86.00	144	484	340	0.43	620
American	1.00E−06	2.83E−03	10668	25	63.28	169	529	360	0.34	483

Note: Assumes Static Head Elevation of 12250 (Lake Emma) and 5 foot fracture distance from each side of the plug.

CASE F

Adit (name)	Permeability (cm/sec)	Permeability (ft/day)	Adit Elevation (feet)	Length of Plug (feet)	Hydraulic Gradient (feet/foot)	Cross Sectional Plug Area ($feet^2$)	Cross Sectional Flow & Plug Area ($feet^2$)	Cross Sectional Flow Area ($feet^2$)	Calculated Flow (gpm)	Calculated Flow (gpd)
Brenneman B	1.00E−06	2.83E−03	12122	3	*	100	400	300	*	*
Brenneman F	1.00E−06	2.83E−03	11562	8	3.75	100	400	300	0.02	24
Terry F	1.00E−06	2.83E−03	11562	8	3.75	144	484	340	0.02	27
American	1.00E−06	2.83E−03	10668	25	36.96	169	529	360	0.20	282

Note: Assumes Static Head Elevation of 11592 ("F" Level plus 30 feet) and 5 foot fracture distance from each side of the plug.

CASE G

Adit (name)	Permeability (cm/sec)	Permeability (ft/day)	Adit Elevation (feet)	Length of Plug (feet)	Hydraulic Gradient (feet/foot)	Cross Sectional Plug Area ($feet^2$)	Cross Sectional Flow & Plug Area ($feet^2$)	Cross Sectional Flow Area ($feet^2$)	Calculated Flow (gpm)	Calculated Flow (gpd)
Brenneman B	1.00E−10	2.83E−07	12122	3	42.67	100	400	300	0.00002	0.03
Brenneman F	1.00E−10	2.83E−07	11562	8	86.00	100	400	300	0.00004	0.05
Terry F	1.00E−10	2.83E−07	11562	8	86.00	144	484	340	0.00004	0.06
American	1.00E−10	2.83E−07	10668	25	63.28	169	529	360	0.00003	0.05

Note: Assumes Static Head Elevation of 12250 (Lake Emma) and 5 foot fracture distance from each side of the plug.

CASE H

Adit (name)	Permeability (cm/sec)	Permeability (ft/day)	Adit Elevation (feet)	Length of Plug (feet)	Hydraulic Gradient (feet/foot)	Cross Sectional Plug Area ($feet^2$)	Cross Sectional Flow & Plug Area ($feet^2$)	Cross Sectional Flow Area ($feet^2$)	Calculated Flow (gpm)	Calculated Flow (gpd)
Brenneman B	1.00E−10	2.83E−07	12122	3	*	100	400	300	*	*
Brenneman F	1.00E−10	2.83E−07	11562	8	3.75	100	400	300	1.66E−06	0.002
Terry F	1.00E−10	2.83E−07	11562	8	3.75	144	484	340	1.88E−06	0.003
American	1.00E−10	2.83E−07	10668	25	36.96	169	529	360	1.96E−05	0.028

Note: Assumes Static Head Elevation of 11592 ("F" Level plus 30 feet) and 5 foot fracture distance from each side of the plug.

Table 6. Sunnyside Mine Ground–Water Flow Around Bulkhead Calculation Sheet

Performed by Bob Butler 12/24/92 revised 12/28/92

CASE I

Adit (name)	Permeability (cm/sec)	Permeability (ft/day)	Adit Elevation (feet)	Length of Plug (feet)	Hydraulic Gradient (feet/foot)	Cross Sectional Plug Area (feet²)	Cross Sectional Flow & Plug Area (feet²)	Cross Sectional Flow Area (feet²)	Calculated Flow (gpm)	Calculated Flow (gpd)
Brenneman B	5.25E−05	1.49E−01	12122	3	42.67	100	400	300	9.9	14,249
Brenneman F	5.25E−05	1.49E−01	11562	8	86.00	100	400	300	19.9	28,722
Terry F	5.25E−05	1.49E−01	11562	8	86.00	144	484	340	22.6	32,551
American	5.25E−05	1.49E−01	10668	25	63.28	169	529	360	17.6	25,360

Note: Assumes Static Head Elevation of 12250 (Lake Emma) and 5 foot fracture distance from each side of the plug.

file: G\SUNNY\LOTUS\PLUGLEAK.WK3

8.0 *MOVEMENT OF WATER FROM FLOODED WORKINGS TO THE SURFACE*

An equilibrium water level is anticipated to occur in the flooding mine workings in less than 10 years (see Section 6). Under equilibrium conditions the rate of inflow to the flooded workings will equal the rate of outflow. The ground-water flow which passes through flooded mine workings is expected to be approximately 70 gpm, but could be as great as 200 gpm. This ground water is expected to discharge over a long stretch of Cement Creek. The travel time from the flooded workings to Cement Creek is estimated at approximately 150 years. Under the very unlikely scenario that the equilibrium water level in the flooded workings is at 12,250 feet msl, some of the water could reach Cement Creek (via the Mogul Mine) in as little as 4 months.

8.1 Nature of the Discharge from Flooded Mine Workings

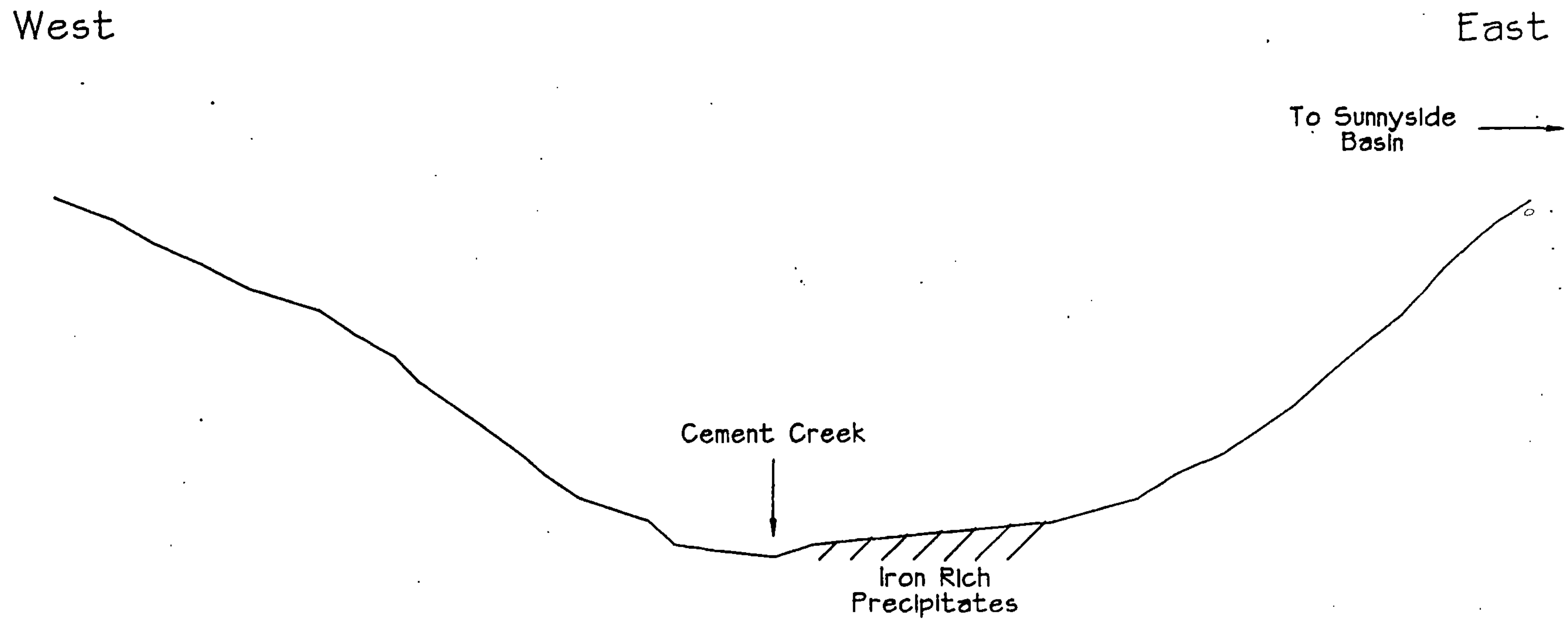
Water leaving the flooded mine workings is expected to move primarily along natural flow paths through fractures in the volcanic rocks until it discharges along Cement Creek. The ground water is expected to move toward Cement Creek because the natural fracture system has enhanced permeability in that direction and because the hydraulic gradient between Sunnyside Basin and Cement Creek is the same as, or greater than, in other directions (Section 3.4).

Based upon the preferred fracture orientation (Section 3.2) the ground water would be expected to move generally southwest from Sunnyside Basin toward Cement

Creek. However, some ground water may also follow pathways along, or parallel to, the Ross Basin fault (Brenneman vein) and Bonita fault. These pathways would allow for ground-water discharge along a stretch of Cement Creek between the Mogul Mine (on the north) and the Silver Ledge Mine (on the south).

A cross section across Cement Creek between the Mogul Mine and Gladstone (near the Red and Bonita Mine) is clearly asymmetrical rather than a classic "V" shape (Figure 10). This asymmetry correlates with the distribution of present and former iron "bogs" and is thought to result from springs depositing mineral precipitates. The build up of precipitates would have gradually forced Cement Creek toward the west. Hence, based upon the local geomorphology ground-water appears to have discharged preferentially along the part of Cement Creek between the Mogul Mine and Gladstone. Furthermore, the discharge appears to have been diffuse rather than concentrated at one spring.

If the equilibrium water level in the mine is significantly higher than expected, some portion of the outflow from the flooded mine workings may discharge to Eureka Gulch. The possible discharge to Eureka Gulch would occur via the more generalized fracture permeability which exists at shallow depths where overburden pressure is relatively less (Section 3.2).



Profile digitized from U.S. Geological Survey "Ironton" 7 1/2 minute topographic map.

Scale: 1"=300'
0 150' 300'

N

Sunnyside Gold Corporation
San Juan County, Colorado

Topographic Profile Across Cement Creek

DATE:	02/11/93
DESIGNED:	
CHECKED:	
APPROVED:	
DRAWN:	RJJ
PROJ.: 201872025	

SIMON

Figure 10

At the expected equilibrium water level, the American Tunnel will be the only man-made pathway out of the mine, and it will be blocked. In case the equilibrium water level is higher than expected, all other man-made pathways out of the Sunnyside Mine will also be blocked with bulkheads (at the Terry Tunnel, F-Level Brenneman, and B-Level Brenneman).

8.2 Estimated Rate of Flow through Flooded Mine Workings

The present rate of discharge from the American Tunnel is rather constant at approximately 1600 gpm. Of this, approximately 930 gpm originates upstream of the proposed bulkhead site near the underground SGC property line. The flow from the American Tunnel is almost all ground water rather than surface water inflow. The flow rates are stable and appear to represent an equilibrium condition.

As discussed in Section 3.4 the pre-mining ground-water movement was from Sunnyside Basin toward Cement Creek. The water entering the American Tunnel upstream of the bulkhead site has merely been captured on its way to Cement Creek and so that its transit time is reduced. The capture zone for water entering the mine workings extends well beyond the mine workings themselves. Therefore, the ground water which will pass through the Sunnyside Mine workings after an equilibrium water level is reached will be far less than 930 gpm.

Darcy's equation can be used to estimate a likely overall rate of ground-water flow expected to pass through the flooded mine workings. Darcy's equation is:

$$Q = KIA \quad \text{where:}$$

Q =	discharge
K =	hydraulic conductivity
I =	gradient, and
A =	the cross-sectional area of the "aquifer" through which water flows.

Based on flow tests in the American Tunnel (Section 5.4), the hydraulic conductivity in unusually fractured areas is estimated at 0.15 feet/day. However, typical hydraulic conductivity is expected to be more than an order of magnitude less.

Darcy's equation was applied to four scenarios in order to obtain a reasonable range of values for the ground-water flow expected to pass through the flooded mine workings (Table 7). Case 1 is considered the most likely, with an equilibrium water level in the mine at F level and a southwest flow direction. Case 1 uses the maximum width of stoped mine workings of 4560 feet. The resulting estimated rate of ground-water flow through the flooded mine workings is approximately 70 gpm. Case 2 is similar to Case 1 except it assumes the absolute maximum possible equilibrium water level of 12,250 feet (land surface in Sunnyside Basin) and results in an estimated flow of 200 gpm. The flow in cases 1 and 2 would be expected to discharge over a long stretch of Cement Creek as discussed in Section 8.1.

Table 7. Estimated Rates of Ground-Water Flow Expected to Pass Through Mine Workings to Cement Creek								
	Equilibrium Water Level in Mine (Feet msl)	Elevation of Discharge Zone (Feet msl)	Gradient	Saturated Thickness[7] (Feet)	Width of Flow Zone (Feet)	Area[8] (Ft^2)	Hydraulic Conductivity (Ft/day)	Discharge (GPM)[11] (rounded)
Case 1	11,562[1]	10,500[3]	.105[5]	894	4560[9]	$4x10^6$	0.03	70
Case 2	12,250[2]	10,500[3]	.18[5]	1582	4560[9]	$7x10^6$	0.03	200
Case 3	11,562[1]	11,400[4]	.06[6]	162	500[10]	$8x10^4$	0.15	4
Case 4	12,250[2]	11,400[4]	.32[6]	450	500[10]	$2x10^5$	0.15	160[13]
		11,850[14]	.67[12]	400	500[10]	$2x10^5$	0.15	

NOTES:

(1) Elevation of F-level (anticipated equilibrium water level in flooded mine workings).

(2) Elevation of land surface in Sunnyside Basin (maximum possible equilibrium water level).

(3) Elevation of Cement Creek near the portal of the American Tunnel. Expected elevation of ground-water discharge would range from 10,500 to 11,400. Hence, the calculation uses the lowest value for elevation and will result in an overestimate of discharge.

(4) Elevation of the Mogul Mine main level (which intersects the Brenneman vein).

(5) Calculated using the distance between the Sunnyside Basin and the American Tunnel portal (9,500 feet).

(6) Uses the scaled distance of 2,640 feet between the nearest stopes in the Sunnyside and Mogul Mines at an elevation of 11,400 feet msl.

(7) Equilibrium Water Level minus Elevation of Discharge Zone. *This probably represents a maximum effective* thickness and is expected to result in an overestimate of flow through the flooded workings.

(8) Saturated Thickness multiplied by Width of Flow Zone.

(9) Maximum width of flooded stoped workings in the Sunnyside Mine.

(10) Assumed width of highly fractured zone associated with the Brenneman vein. This is probably an overestimate and is expected to result in an overestimate of discharge via the Brenneman vein.

(11) Discharge calculated as Gradient times Area times Hydraulic Conductivity. As discussed in previous footnotes, these estimates may be somewhat high due to conservative assumptions.

(12) Uses the scaled distance of 600 feet between the nearest stopes in the Sunnyside and Mogul Mines at an elevation of 11,850 feet msl.

(13) This number results from adding the flow via the two paths. One path drains at the Mogul Mine main level. The other path drains at the Mogul #3 level.

(14) Elevation of the Mogul #3 level (which intersects the Brenneman vein).

Cases 3 and 4 assume ground water preferentially moving along the Brenneman vein and use the high hydraulic conductivity found in unusually fractured areas. Since the flow from the Brenneman vein is approximately equal to the flow in the area of the American Tunnel flow tests, it is reasonable to assume that the hydraulic conductivities are also similar. The width of enhanced fracture permeability is assumed to be 500 feet for the calculation, but it is probably less. If ground water does move along the Brenneman vein it will encounter the Mogul Mine workings at a distance of 2640 feet at an elevation of 11,400 feet. Case 3 assumes the expected equilibrium water level at F level and results in an estimated flow of 4 gpm. Case 4 assumes the absolute maximum possible equilibrium water level of 12,250 feet and results in an estimated flow of 160 gpm. The flow in cases 3 and 4 would discharge from the portal of the Mogul Mine.

When considering possible flow along the Brenneman vein, it should be emphasized that no flow is expected to take this route unless the equilibrium water level in the flooded mine workings exceeds 11,400 feet msl (the elevation of the Mogul Mine main level). At an equilibrium water level above 11,400 feet, ground water could begin to move via fracture permeability toward the Mogul Mine. Although a tunnel connection between the Sunnyside and Mogul Mines exists at an elevation of 11,904 feet msl, the actual tunnel connection is not expected to serve as a significant conduit for water movement. At the proposed bulkhead sites at both the F-level Brenneman and the B-level Brenneman, the bulkheads would actually consist of a pair of bulkheads at each site. Each member of each pair of bulkheads would be constructed to the specifications recommended by Abel (1993) for a single bulkhead. The twinned bulkheads are proposed to be separated by a distance of more than 100 feet. The purpose of twinning the bulkheads is to reduce the chances of a random permeable fracture set in the rock bypassing a single bulkhead.

8.3 Transit Time for Flow from Mine Workings to the Surface

The time required for ground water to move from the flooded mine workings to Cement Creek can be roughly estimated with a form of Darcy's equation:

$$V = \frac{KI}{n} \quad \text{Where:}$$

$V =$ velocity,
$K =$ hydraulic conductivity,
$I =$ gradient, and
$n =$ effective porosity.

Assuming flow is to the southwest (as in cases 1 and 2 in Section 8.2), possible gradients range from 0.1 assuming a hydraulic head in the Sunnyside Basin to be just below F-Level (the most likely case), to a maximum of 0.18 (assuming a head in the Sunnyside Basin to be at land surface). Hydraulic conductivity in highly fractured areas is on the order of $5x10^{-5}$ cm/sec (0.15 ft/day) based on flow testing in the American Tunnel. However, this hydraulic conductivity is expected to be higher than average considering that the degree of fracturing is somewhat greater than normal in the vicinity of the flow testing. Average hydraulic conductivity is expected to be far less than 0.15 feet/day and is assumed to be 0.03 feet/day for the most likely case. Porosity for fractured crystalline rock ranges up to 10% (Driscoll, 1986, p.67). Considering the high flow rates measured during testing, the porosity is unlikely to be less than 1 percent.

The first part of Table 8 lists the probable minimum, most likely, and probable maximum velocities and transit times of ground water between the flooded mine workings and diffuse discharge along Cement Creek. The second part of Table 8 lists the most likely and probably maximum velocities and transit times of ground water which might follow the Brenneman vein and intersect the idle workings of the Mogul Mine. If the equilibrium water level is approximately at F level (as expected) then the majority of the water passing through the flooded workings (estimated at 70 gpm) is expected to take over 150 years to reach Cement Creek, but a lesser amount (estimated at 4 gpm) may move via the Brenneman vein and have a transit time of approximately 16 years. In the unlikely event that the maximum possible equilibrium water level is reached, the estimated transit times would be reduced to about 10 and 1.5 years, respectively.

Table 8.	*Velocity and Travel Time for Ground-Water Flow Between Mine Workings and Cement Creek*				
	Gradient	Hydraulic Conductivity Ft/Day	Porosity	Velocity Ft/Day	Time in Years
Assuming Southwest Flow and Diffuse Discharge Along Cement Creek					
Slow Case	.10[1]	0.003	.05	.006	4300
Most Likely Case	.105[1]	0.03	.02	.01	160
Fast Case	.18[2]	0.15	.01	2.7	9.6
Assuming Flow Along Brenneman Vein and Discharge Via Mogul Mine					
Most Likely Case	.06[1]	0.15	0.02	0.45	16
Fast Case	.67[2]	0.15	0.02	5.0	0.32

(1) Assumes the expected equilibrium water level at F-level

(2) Assumes the unlikely equilibrium water level at land surface in the Sunnyside Basin.

9.0 WATER CHEMISTRY AFTER INSTALLATION OF PROPOSED BULKHEADS

9.1 Introduction and Methodology

This section summarizes the results of numerical modeling of the geochemical questions associated with the proposed system of bulkheads: estimating the approximate chemistry of the impounded water, identifying what, if any, reactions may occur as impounded water moves either through the country rock around the bulkheads or as it moves through the natural fracture system back to the ground surface, predicting the character of the discharging water once it equilibrates to the atmosphere and precipitates any oversaturated minerals, and, finally, estimating the impact of the discharged water on the overall chemistry of Cement Creek. Numerical geochemical modeling is the computer-based simulation of the complex systems of rock-water interactions. It permits the simultaneous consideration of numerous chemical equilibria states and reactions among solid, aqueous and gaseous species. Geochemical modeling is valued as a check on conceptual models because it permits 1) examination of a total chemical system, as well as critical subsets of that system, 2) protection against oversights that can occur when complex systems are oversimplified, and 3) rapid investigation of modified or alternative expressions of the conceptual model.

The model used was MINTEQA2, versions 3.0 and 3.11. This is a metal speciation program developed by Battelle Northwest Laboratories and distributed by the United

States Environmental Protection Agency through the Center for Exposure Assessment Modeling, Athens, Georgia. The program was developed to model adsorptive retardation and quasi-equilibrium speciation of most metals of environmental concern and permits independent assignment of oxidation state to each of 25 redox pairs among metals. For this project, the adsorptive routines were not used, and the model was run as a full equilibrium model. The program is described in the EPA document "MINTEQA2/PRODEFA2, A Geochemical Assessment Model for Environmental Systems: Version 3.0 User's Manual" (Allison, et al., 1991).

The objectives of the modeling were:

- Model the chemistry of waters associated with the proposed American Tunnel bulkhead system
  - Establish in-situ water characteristics (reference water) and compare to current mine drainage;
  - Project chemistry of water impounded behind deepest bulkhead of the American Tunnel; and
  - Identify reactions likely to occur along flow paths.
- Model the chemistry of water associated with the proposed Terry Tunnel bulkhead system
  - Model a reference water for the shallow mine levels;
  - Project chemistry of water impounded behind bulkhead in the Terry Tunnel; and
  - Identify reactions likely to occur along flow paths.
- Model surface discharge of reference waters and mixed waters; and
- Investigate the impact of discharge waters on surface water chemistry.

Details of the modeling are included in Appendix C of this report. This section contains a summary of the results of the modeling.

9.2 Impounded Water at the American Tunnel Level

Water that will be impounded behind the American Tunnel is conceptualized as ground water from the fractured volcanic rocks that make up the country rock. Whole water analyses of this water were collected from drill holes extending several hundreds of feet back from the tunnel and are the best estimate of the bulk water chemistry. The chemical analyses of these drill hole waters are shown in Table 9.

Integrating the data from these and other whole water analyses from the deeper portions of the American Tunnel, metals-only analyses, petrographic data (Appendix D and Casadevall and Ohmoto) and local and regional geology produced a modeled reference water for the American Tunnel. This reference water is descriptive of both the in-situ ground water of the country rock and of the water that will be impounded behind the American Tunnel bulkhead. The composition of this water is shown in Table 10. The reference water is a calcium sulfate water with significant bicarbonate concentrations. Based on being in equilibrium with both calcite and pyrite the modeled water is strongly reduced (pE = -2.5) and is slightly basic of neutral (pH = 7.2).

MINTEQA2 shows the reference water to be at saturation or equilibrium with both the rock-forming minerals of the country rock and with the principal ore and vein minerals that would be associated with the migration paths to the surface. There should be no significant reaction between the American Tunnel reference water and minerals

Table 9. Water analyses from the American and Terry Tunnels

This table gives the results of laboratory analyses.

Location	Date	Source	Flow MGD	Field pH	Field Conduct	Field Temp deg-C	Lab pH	Lab Conduct	TDS	TSS
AMERICAN TUNNEL										
DH-781	10/07/91	pipe		7.32	1140	13	7.06	1540	1360	6
DH-778	10/07/91	pipe		7.54	1200	12.8	6.39	1610	1420	63
DH-778	01/04/93	pipe					7.50	1810	1600	4
TERRY TUNNEL										
Upstream of Lime Treatment	06/11/91	ditch	1.30	5.60		10.0	5.33	528	359	92
Upstream of Lime Treatment	06/17/91	ditch	1.80	4.40		9.9	4.2	587	426	166
Upstream of Lime Treatment	07/11/91	ditch	0.33	4.10			3.32	933	726	54

Location	Major Anions Sulfate	Bicarb	Fluoride	Chloride	Major Cations Ca	Na	Mg	Sr	Al	K	Si
AMERICAN TUNNEL											
DH-781	905	102.0	1.33	<0.1	390	4.6	6.2	4.99	0.8	<.1	
DH-778	925	153.0	2.97	<0.1	414	3.0	4.0	3.78	0.6	<.1	
DH-778	1100	104.0	0.92	1.30	400	6.3	44.0	13.70	0.1	0.40	>3.7
TERRY TUNNEL											
Upstream of Lime Treatment	264	3.05	2.37	1.42	55.7	1.5	33.9	0.56	0.9	1.14	
Upstream of Lime Treatment	300	0.00	3.38	5.31	117.0	2.2	0.1	0.61	1.5	1.73	
Upstream of Lime Treatment	544	0.00	5.56	0.30	160.0	1.7	19.0	0.98	3.2	1.20	

Location	Metals Iron (Diss)	Iron (Total)	Mn (Diss)	Mn (Total)	Zinc (Diss)	Zinc (Total)	Lead (Diss)	Lead (Total)	Cadmium (Diss)	Cadmium (Total)	Copper (Diss)	Copper (Total)
AMERICAN TUNNEL												
DH-781	<.05		1.17		0.05		0.02		<.002		<.01	
DH-778	1.59		6.91		4.25		<.02		0.030		<.01	
DH-778	<.05	0.13	1.21	1.25	<.01	<.01	<.005	<.005	<.002	<.002	0.01	0.01
TERRY TUNNEL												
Upstream of Lime Treatment	0.1		29.1		20.1	20.41	0.06	1.00	0.09	0.06	1.43	1.83
Upstream of Lime Treatment	0.7		37.4		25.3		0.06		0.02		2.77	
Upstream of Lime Treatment	4.1	13.2	76.8	77.8	47.3	47.6	0.88	1.05	0.19	0.19	5.05	5.11

Location	Metals (con't.) Mercury (Diss)	Mercury (Total)	Arsenic (Diss)	Boron (Diss)	Chromium (Diss)	Gold (Diss)	Selenium (Diss)	Silver (Diss)
AMERICAN TUNNEL								
DH-781	<.001		<.005	<.01	<.02	<.05	<.005	<.01
DH-778	<.001		<.005	<.01	<.02	0.060	<.005	<.01
DH-778	<.001	<.001	<.005		<.02	0.005	<.005	0.030
TERRY TUNNEL								
Upstream of Lime Treatment	<.0002	<.0002	<.002	<.05	<.02	<.05	<.002	<.01
Upstream of Lime Treatment	<.0002		<.002	<.01	<.02	<.05	<.002	<.01
Upstream of Lime Treatment	<.0002	<.0002	0.008	0.08	<.02	<.05	<.002	<.01

Table 10. Reference waters
(THIS TABLE GIVES THE RESULTS OF MINTEQA2 MODELING)

AMERICAN TUNNEL		TERRY TUNNEL	
Analyte	*Concentration mg/L*	*Analyte*	*Concentration mg/L*
Sulfate	925	Sulfate	544
Bicarbonate	150	Bicarbonate	6.41
Chloride	0.05	Chloride	0.3
Fluoride	2.97	Fluoride	5.56
Phosphate	0.007		
		Calcium	160
Calcium	414	Magnesium	19
Magnesium	4.03	Sodium	1.7
Sodium	2.99	Aluminum	3.2
Aluminum	0.6	Potassium	1.2
Potassium	0.05	Silica	5.3
Silica	5.93		
		Iron	13.24
Iron	2.75	Manganese	77.78
Manganese	8.08	Copper	5.11
Zinc	5	Zinc	47.6
Strontium	3.78	Strontium	0.98
Cadmium	0.04	Cadmium	0.19
Lead	0.025	Lead	1.05
pH	7.18	pH	7.01
pE	−2.46	pE	−1.50

along either migration around the bulkhead or along the fracture network back to the surface and therefore no significant changes in water chemistry.

9.3 Impounded Water at the Terry Tunnel Level

Drainage from the Terry Tunnel that will be diverted into the mine workings and potentially impounded by a bulkhead to be placed in the Terry Tunnel is a composite flow of water drainage into the mine workings through surface openings and unsaturated flow through the vadose zone. The only available samples of the Terry Tunnel water are mixes of these sources of water. Table 9 shows the available whole water analyses of Terry Tunnel mine drainage.

Integrating the data from the whole water analyses with analyses of metals-only, petrographic data and regional and local geologic information permitted a Terry Tunnel reference water to be modeled. This reference water is descriptive of the water that will likely be impounded by a Terry Tunnel bulkhead and is believed to be representative of, and dominantly controlled by, the flow through natural fractures and unsaturated flow through the vadose zone. The composition of the Terry Tunnel reference is shown in Table 10. This reference water is also a calcium sulfate water but with very reduced bicarbonate concentrations. Both in-situ and when impounded, it is believed to be neutral (pH estimated at 7.0) and reduced (but not as reduced as the American Tunnel water). Although the total dissolved solids concentration is less than that of the American Tunnel reference water, the individual and total metals load is substantially higher. Copper is present in the Terry Tunnel reference water, whereas it was not present in the ground water at the American Tunnel level in consistently detectable concentrations.

MINTEQA2 calculations show the Terry Tunnel reference water to be at equilibrium or oversaturated with most of the major rock-forming minerals that are present in the country rock at that level. The impounded water is expected to be somewhat unsaturated with respect to calcite. The overall reaction with country rock should be minimal and will probably decrease matrix permeability with time. The lower sulfate concentration of the Terry Tunnel reference water (relative to the American Tunnel reference water) is offset by correspondingly elevated concentrations of metals. Consequently, the Terry Tunnel reference water is also essentially at equilibrium with major ore minerals and should be non-reactive with them along the migration path. There may be some dissolution of rhodochrosite, which would further neutralize the water and increase its buffering capacity.

Dilute, oxidized surface water that may enter the mine workings should be decreased in the future as a result of surface water diversions under construction above the mine workings. Any such water that does enter is expected to be driven toward reference water composition by dissolution of ore minerals it comes in contact with along the flow paths.

9.4 *Overall Chemistry of Impounded Water Expected to Move through the Ground-Water System*

Water within the flooded workings is anticipated to represent a mix of American Tunnel and Terry Tunnel reference waters. At deeper levels, chemistry similar to the American Tunnel reference water is expected to dominate, and at shallower levels the chemistry will be most like the Terry Tunnel reference water. Engineering efforts are being enacted to inhibit turnover within the flooded workings, so uniform mixing is less likely within the mine workings than is a somewhat stratified transition between end members. Further mixing between mine waters, and with ground water, is expected to occur as the water moves through the natural fracture system toward Cement Creek. Modeling of 4:1 and 1:1 (American Tunnel:Terry Tunnel) mixes of the reference waters indicates that much of the metals load is likely to precipitate out of solution within the mine workings, due to reducing conditions. This process is an analog to the natural processes of supergene enrichment of ore bodies. In order to be conservative, this likely precipitation was not permitted, and total metals load was retained. Hence, the modeling may yield a somewhat greater metals load than is expected.

9.5 *Anticipated Chemistry of Surface Discharge*

Surface discharge of the compounded water was simulated by equilibrating the reference waters and the two mixes of reference waters to atmospheric concentrations of CO_2 and O_2 and then permitting oversaturated minerals to precipitate. The suite of precipitated minerals, dominantly metal oxides (or hydroxides) and carbonates, drops most of the metals from solution. This is analogous to the natural processes which form the iron "bogs" in the area. Table 11 shows the composition of the modeled discharge water for each of the reference waters and each of the modeled mixes.

9.6 Effects of Discharge on Cement Creek

The environmental impact of the surface drainage can be assessed in part by comparing the anticipated composition of the discharge to present surface water drainage into which the discharge will eventually flow. In this case, that surface drainage is Cement Creek. That comparison is made between the two modeled mixed waters and Cement Creek at periods of high and low flow in Table 12. Also included in Table 12 are the results of a flow-proportionate mix of the discharge waters with the creek waters at high and low discharge. There is no discernable impact on Cement Creek water quality that will result from mixing the modeled discharge waters with the surface drainage. The only significant difference between the waters is that the modeled discharge is of higher pH and contains considerably more carbonate buffering than Cement Creek. The result of such mixing could be to increase Cement Creek's buffering capacity and/or decrease the acidity of this stream.

Based upon the concentrations of the modeled discharge water and the probable discharge volume, with the conservative assumption of no other losses, such as adsorption of dissolved metals on precipitated oxides, the installation of these

Table 11. Modeled Discharge Water Quality

AMERICAN TUNNEL		4:1 MIX AMERICAN TUNNEL TO TERRY TUNNEL		1:1 MIX		TERRY TUNNEL	
MINTEQA2 Component	mg/L	MINTEQA2 Component	mg/L	MINTEQA2 Component	mg/L	MINTEQA2 Component	mg/L
SO_4^{--}	926	SO_4^{--}	850	SO_4^{--}	735	SO_4^{--}	544
CO_3^{--}	33.9	CO_3^{-}	33.4	CO_3^{--}	13.9	CO_3^{--}	0.77
Cl^-	0.05	Cl^-	0.10	Cl^-	0.18	Cl^-	0.30
F^-	1.11	F^-	1.00	F^-	1.09	F^-	5.56
Ca^{++}	337	Ca^{++}	361	Ca^{++}	284	Ca^{++}	160
Mg^{++}	4.04	Mg^{++}	7.03	Mg^{++}	11.5	Mg^{++}	19.0
Na^+	3.00	Na^+	2.74	Na^+	2.35	Na^+	1.70
Al^{+++}	ND	Al^{+++}	ND	Al^{+++}	ND	Al^{+++}	3.08
K^+	0.05	K^+	0.28	K^+	0.63	K^+	1.20
H_4SiO_4	ND	H_4SiO_4	ND	H_4SiO_4	ND	H_4SiO_4	ND
Fe^{+++}	ND	Fe^{+++}	ND	Fe^{+++}	ND	Fe^{+++}	ND
Mn^{++}	ND	Mn^{++}	ND	Mn^{++}	ND	Mn^{++}	ND
Zn^{++}	0.97	Cu^{++}	0.26	Cu^{++}	0.24	Cu^{++}	5.11
Sr^{++}	3.79	Zn^{++}	8.98	Zn^{++}	22.5	Zn^{++}	47.6
Cd^{++}	0.006	Sr^{++}	3.23	Sr^{++}	2.38	Sr^{++}	0.98
Pb^{++}	0.025	Cd^{++}	0.01	Cd^{++}	0.04	Cd^{++}	0.19
pH	7.87	Pb^{++}	0.18	Pb^{++}	0.44	Pb^{++}	1.05
pE	13.81	pH	7.82	pH	7.82	pH	2.60
		pE	14.18	pE	14.18	pE	19.68

PRECIPITATED MINERALS:

	mg precipitated per liter of solution		mg precipitated per liter of solution		mg precipitated per liter of solution		mg precipitated per liter of solution
Calcite	191.171	Pyrolusite	34.88	Pyrolusite	68.00	Pyrolusite	122.93
Pyrolusite	12.780	$ZnSiO_3$	8.55	Hematite	11.20	Hematite	16.78
$ZnSiO_3$	8.728	Hematite	6.55	$ZnSiO_3$	8.27	Ca−Nontronite	5.72
Fluorite	3.826	Fluorite	5.15	Fluorite	6.56		
Hematite	3.944	Tenorite	5.1	Diaspore	4.23		
Diaspore	1.338	ZnO (Active)	4.24	Brochantite	3.86		
Otavite	0.052	Diaspore	2.49	Otavite	0.12		
		Otavite	0.10	Cerussite	0.12		
		Plattnerite	0.06				

Table 12. Comparison of modeled discharge water with chemistry of Cement Creek

Date	Source	Flow MGD	Field pH	Field Temp deg–C	Lab pH	Major Anions Sulfate	Bicarb	Fluoride	Chloride
05/31/89	Cement Creek	15.67	3.9	12.0	4.1	50		4.8	
07/02/87	Cement Creek	11.47	3.9	8.8	4.2	60	0.0	0.4	0.0
	4:1 Spring Wtr	0.11	7.8	9.0		850	33.4	1.0	0.1
	1:1 Spring Wtr	0.11	7.4	9.0		735	13.9	1.1	0.2
03/29/91	Cement Creek	0.32	4.2	5.0	4.5	462	0.0	2.2	3.1
02/11/91	Cement Creek	0.23	5.7	1.9	3.5	439	0.0	3.1	2.0

Date	Source	Major Cations Ca	Na	Mg	Al	K	Metals Iron (Diss)	Mn (Diss)	Zinc (Diss)	Copper (Diss)	Lead (Diss)	Cadmium (Diss)
05/31/89	Cement Creek	17	8.4	0.2	1.8	0.9	1.2	0.5	1.4	0.24	0.04	0.01
07/02/87	Cement Creek	16	1.0	4.0	0.8	0.0	0.7	1.0	3.8	0.13	ND	0.03
	4:1 Spring Wtr	361	2.7	7.0	0.0	0.3	0.0	0.0	9.0	0.26	0.18	0.01
	1:1 Spring Wtr	284	2.4	11.5	0.0	0.6	0.0	0.0	22.5	0.24	0.44	0.04
03/29/91	Cement Creek	147	2.3	14.1	5.2	0.6	0.3	6.8	6.0	0.26	0.25	0.02
02/11/91	Cement Creek	135	4.1	15.2	6.7	0.7	1.1	8.3	7.4	0.40	0.29	0.07

Cement Creek water quality after bulkhead installation:		Major Anions Sulfate	Bicarb	Fluoride	Chloride	Major Cations Ca	Na	Mg	Al	K
High flow and 4:1 mix	13.68	61	0.3	2.9	0.0	19	5.3	1.8	1.4	0.5
Low flow and 4:1 mix	0.385	566	9.5	2.1	1.9	205	3.0	12.4	4.2	0.5
High flow and 1:1 mix	13.68	60	0.1	2.9	0.0	19	5.2	1.9	1.4	0.5
Low flow and 1:1 mix	0.385	533	4.0	2.1	1.9	183	2.9	13.7	4.2	0.6

Cement Creek water quality after bulkhead installation:	Metals Iron (Diss)	Mn (Diss)	Zinc (Diss)	Copper (Diss)	Lead (Diss)	Cadmium (Diss)
High flow and 4:1 mix	1.0	0.7	2.4	0.19	0.02	0.02
Low flow and 4:1 mix	0.5	5.3	7.3	0.30	0.24	0.03
High flow and 1:1 mix	1.0	0.7	2.5	0.19	0.03	0.02
Low flow and 1:1 mix	0.5	5.3	11.1	0.30	0.32	0.04

bulkheads should deliver the following metals load (lbs/day) to Cement Creek: iron, <.1; manganese, <.1; zinc, 8.1 to 20.3; cadmium, .009 to .036; lead, .16 to .40; and copper, .22 to .23.

9.7 *Acid-Generating Potential of Wall Encrustations*

The previous parts of Section 9 have considered the most likely effect that country rock and primary vein mineralization will have on impounded water and vice-versa. Secondary mineralization (encrustations on mine walls formed after tunnel construction) is considered in this section. At some other mines, wall encrustations have been shown to have significant acid-generating potential.

Coatings of secondary minerals are relatively rare on the walls of the accessible parts of the Sunnyside Mine. The general lack of secondary mineralization is probably due to the overall low permeability of the fractured volcanic rocks which results in mine walls being quite dry in most places.

During December, 1992, a Simon Hydro-Search hydrogeologist was taken to locations where SGC staff had remembered seeing mineral crusts on the walls of the mine. Mineral crusts were scraped from the walls and placed in rock sample bags for future analysis.

Table 13 summarizes the results of the analyses of the wall scrapings. The complete laboratory report including methodology is given in Appendix E. Wall scrapings from below B-level (nominal elevation of 12,250 feet) all had a paste pH of greater than 4.5. A paste pH represents a minimal amount of water added to a sample and will typically yield a worst case pH. A paste pH of greater than 4.5 indicates a very low potential for acid generation.

The three wall scrapings from B-level all had a paste pH of less than 4.0 and warranted further evaluation. Samples 1-5 were all mixed with a weakly buffered solution which simulated the measured buffering capacity of Terry Tunnel water. The solution resulting from sample 5 (from B-level) showed a pH of 5.7 after mixing with 100 parts of weakly buffered water to one part of sample. The solutions resulting from sample 4 showed a pH of 6.7 after mixing 1000 parts of weakly buffered water to one part of sample. The actual ratio of water filling the tunnels to volume of wall coatings is greater than 1000 to 1 even if only the immediate vicinities of the wall coatings are considered. The solution resulting from sample 3 had a pH of 4.9 after mixing 10,000 parts of weakly buffered water to one part of sample. The mineral encrustation where sample 3 was taken covered an area of only 2 by 6 feet, so only a small volume of mine workings would have to be flooded to counteract the effects of this zone. If the full volume of the mine is considered, the acid-generating capacity of the observed wall scrapings is insignificant.

Table 13: Acid-Generating Potential of Mineral Encrustations on Walls

Sample Number	Location	Paste pH	Slurry pH 1 part sample in 100 parts of solution	Slurry pH 1 part sample in 1000 parts of solution	Slurry pH 1 part sample in 10,000 parts of solution
1	F-Level, 100' East of proposed bulkhead site	4.62	6.60	---	---
2	F-Level Brenneman vein localized, brown-black mud flowstone, located 100 feet toward Washington Shaft from proposed bulkhead	6.10	6.05	---	---
3	B-Level, near proposed bulkhead site, localized white flowstone 2 x 6 foot zone	2.49	2.75	3.6	4.9
4	B-Level, near proposed bulkhead, ¼" thick local deposit, brown flowstone	3.11	3.45	6.7	---
5	B-Level, Washington Vein near Washington vertical shaft-wall scraping 1/16" thick	3.56	5.70	---	---
6	D-Level, wall scrape, 2700 stope, localized flowstone	6.50	---	---	---

The only observed secondary mineralization with acid-generating potential was on B-level at an elevation of approximately 12,250 feet msl. The expected equilibrium water level of the flooded mine workings (if surface water inflow to the mine from Sunnyside Basin is largely abated) is just below F-level. Hence, all of the sampled mineral crusts are expected to be above the equilibrium water level. The only observed mineral crusts with significant acid-generating capacity were at an elevation of 12,250 feet: over 700 feet higher than the expected equilibrium water level. Hence, stored acidity in secondary mineralization is not expected to be a significant problem.

10.0 REFERENCES

Abel, John F., Jr., 1992, Bulkhead Design for the Sunnyside Mine: Sunnyside Gold Corp., An Echo Bay Company, December 9, 1992, 49 p.

Allison, Jerry D., David S. Brown and Kevin J. Novo-Gradac, 1991, MINTEQA2/PRODEFA2, A Geochemical Assessment Model for Environmental Systems: Version 3.0 User's Manual; United States Environmental Protection Agency, EPA/600/3-91/021.

Bird, A. G., 1986, Silverton Gold, The Story of Colorado's Largest Gold Mine, 137 p.

Burbank, W. S., 1960, Pre-Ore Propylitization, Silverton Caldera, Colorado, U.S. Geol. Survey Prof. Paper 400-B, p. B12-B13.

Burbank, Wilbur S., and Robert G. Luedke, 1969, Geology and Ore Deposits of the Eureka and Adjoining Districts, San Juan Mountains, Colorado; United States Geologic Survey Professional Paper 535, 8 pl., 15 fig., 15 tb., 72 p.

Casadevall, Tom and Hiroshi Ohmoto, 1977, Sunnyside Mine, Eureka Mining District, San Juan County, Colorado: Geochemistry of Gold and Base Metal Ore Deposition in a Volcanic Environment; Economic Geology, v.72, pp. 1285-1320.

Cooper, H.H., Jr. and C.E. Jacob, 1946, A generalized graphical method for evaluating formation constants and summarizing well field history. Trans. Amer. Geophys. Union, 27, pp. 526-534.

Langston, D.J., 1978, The Geology and Geochemistry of the Northeasterly Gold Veins, Sunnyside Mine, San Juan County, Colorado, Colorado School of Mines/M.S. thesis, 153 p.

Simon Hydro-Search, Inc., 1992, Preliminary Characterization of the Hydrology and Water Chemistry of the Sunnyside Mine and Vicinity, San Juan County, Colorado, February 11, 1992, 53 p.

Siskind, D.E. and R.R. Fumanti, 1974, Blast-Produced Fractures in Lithonia Granite, Report of Investigations 7901, U.S. Bureau of Mines, 38 p.

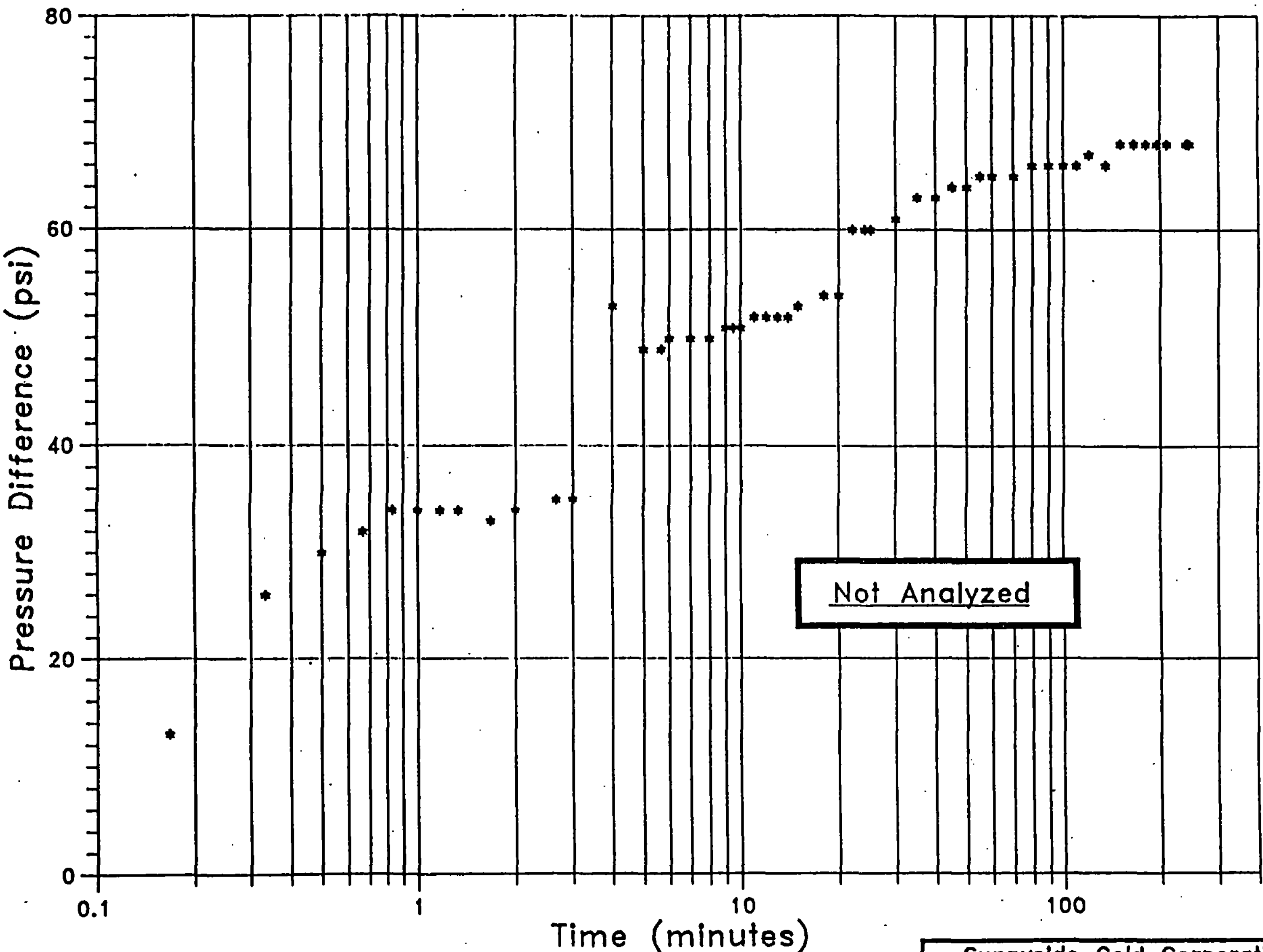
Steven, T.A., and Lipman, P.W., 1976, Calderas of the San Juan Volcanic Field, Southwestern Colorado, U.S. Geol. Survey Prof. Paper 958, 35 p.

Worsey, P.N., 1985, Measurement of Blast Induced Damage in Wall Rock for a Selection of Underground Perimeter Blasting Techniques, in Proceedings of the Eleventh Conference on Explosives and Blasting Techniques, Society of Explosives Engineers, pp. 175-189.

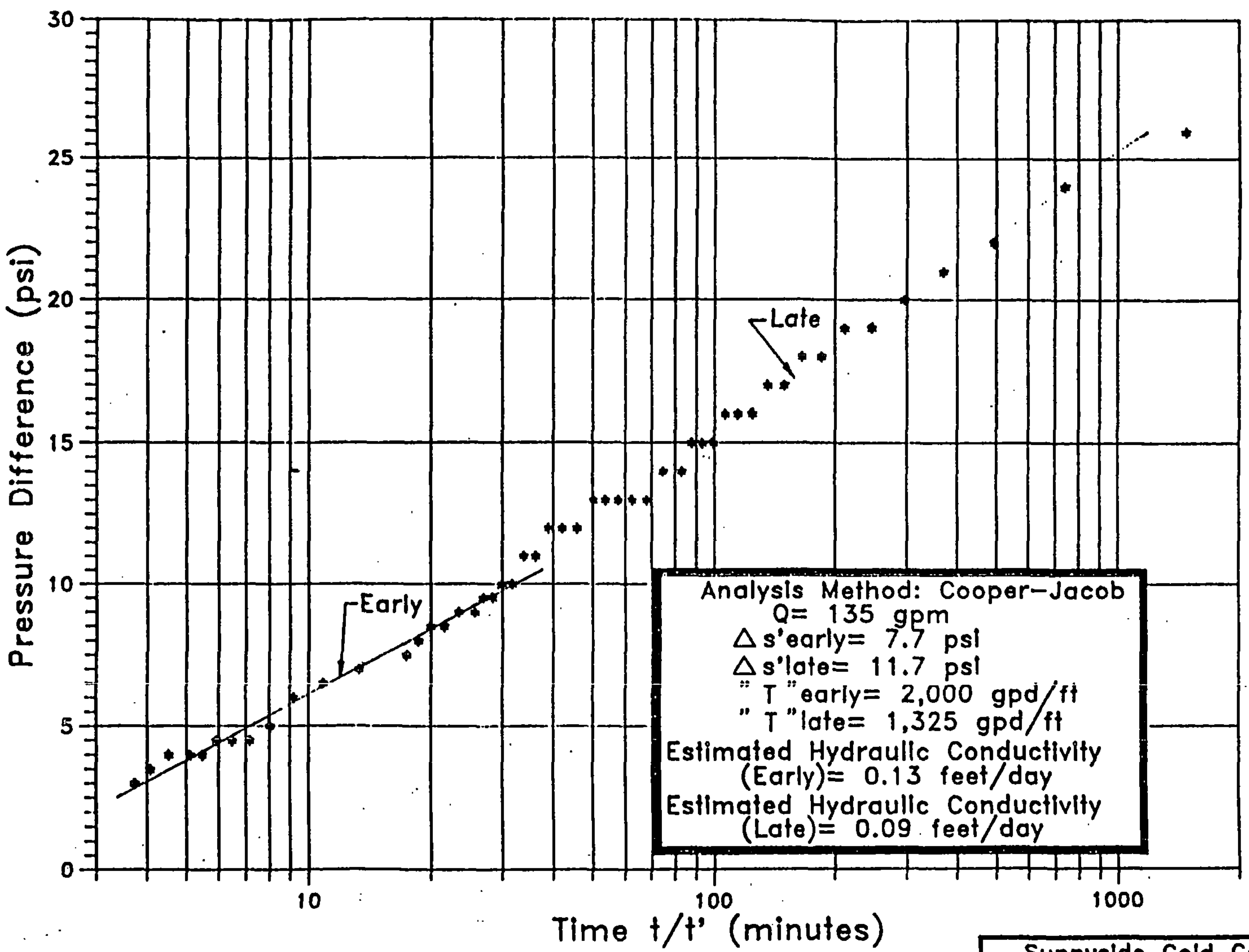
Worsey, P.N., 1986, The Quantitative Assessment of Blast Damage in Highway Rock Cuts and Tunnel Profiles by Seismic Refraction Surveys, Rock Mechanics and Explosives Research Center, University of Missouri, Rolla, Missouri, 22 p.

APPENDIX A

Results of Flow Testing in the American Tunnel

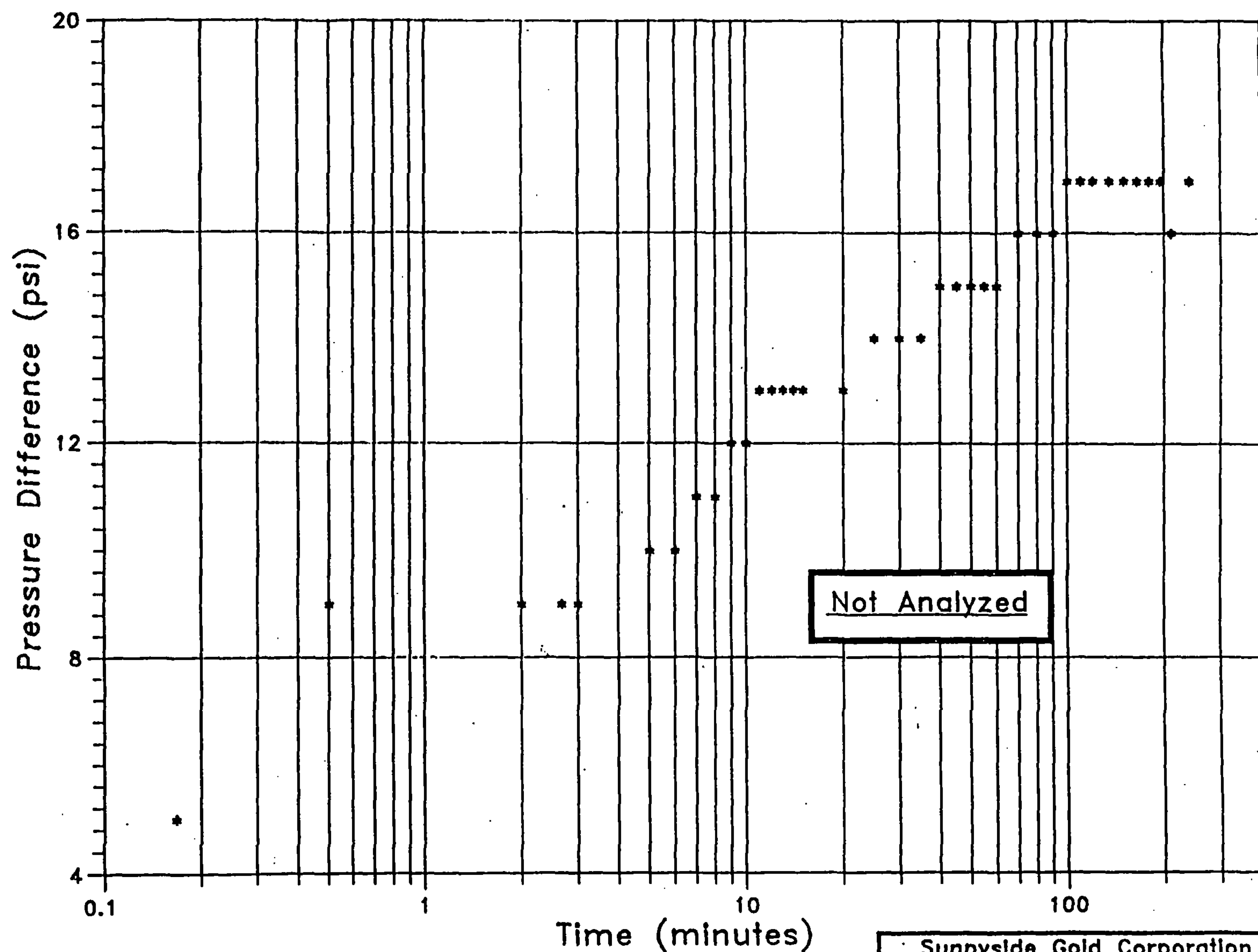


Sunnyside Gold Corporation San Juan County, Colorado	DATE: 03/05/93
	DESIGNED: ROW
700 Hole Drawdown Test	CHECKED: RGB
	APPROVED:
	DRAWN: RJJ
	PROJ.: 187112251
SIMON HYDRO-SEARCH	Figure A-1

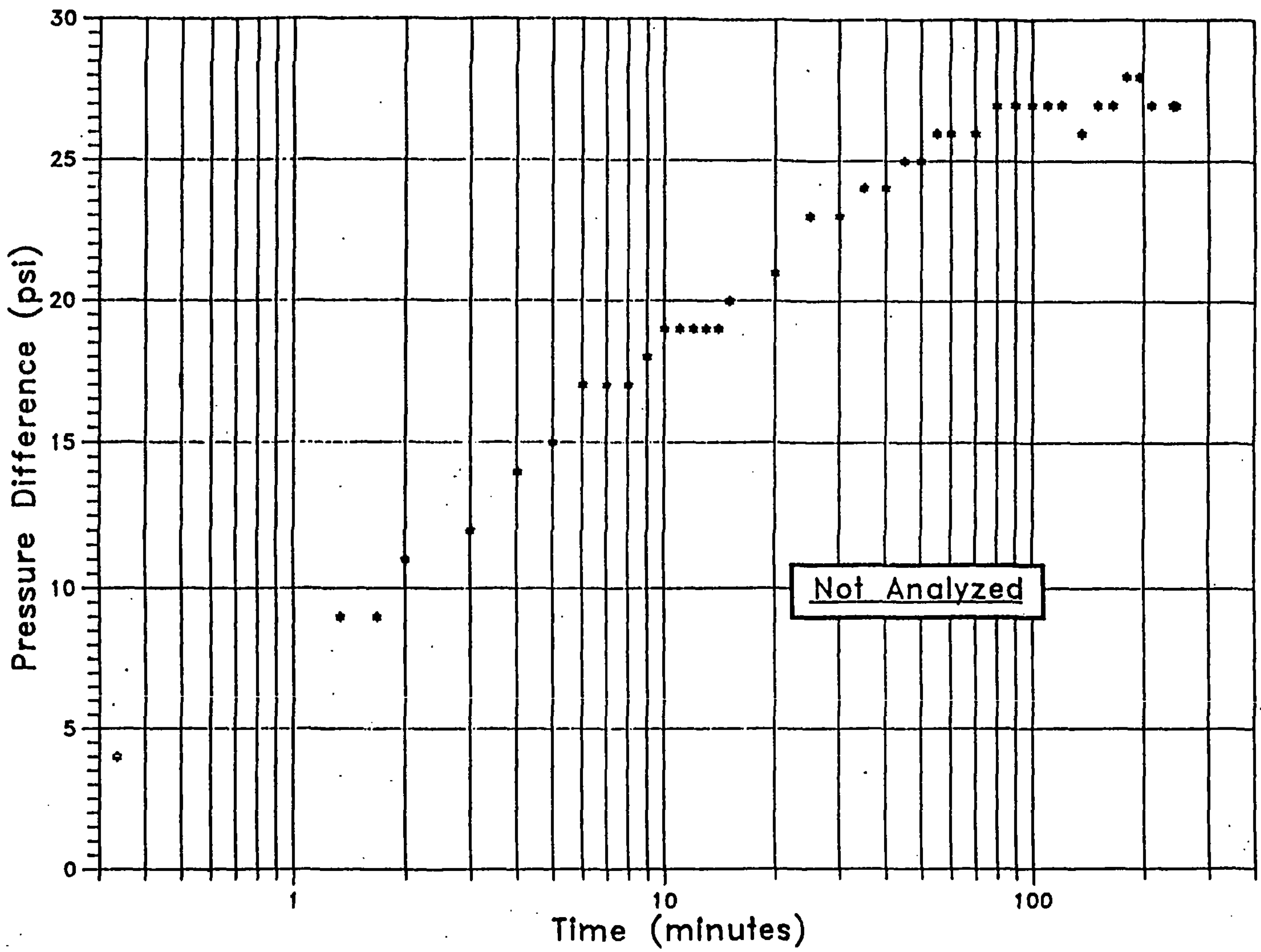


Sunnyside Gold Corporation San Juan County, Colorado		DATE:	03/05/93
		DESIGNED:	ROW
700 Hole Recovery Test		CHECKED:	RGB
		APPROVED:	
		DRAWN:	RJJ
		PROJ.:	187112251
SIMON HYDRO-SEARCH		**Figure A-2**	

/usr4/sunnysde/18711225/187gr002.DVG



Sunnyside Gold Corporation San Juan County, Colorado	DATE: 03/05/93
702 Hole Drawdown Test	DESIGNED: ROW CHECKED: RGB APPROVED: DRAWN: RJJ PROJ.: 187112251
SIMON HYDRO-SEARCH	Figure A-3



Sunnyside Gold Corporation
San Juan County, Colorado

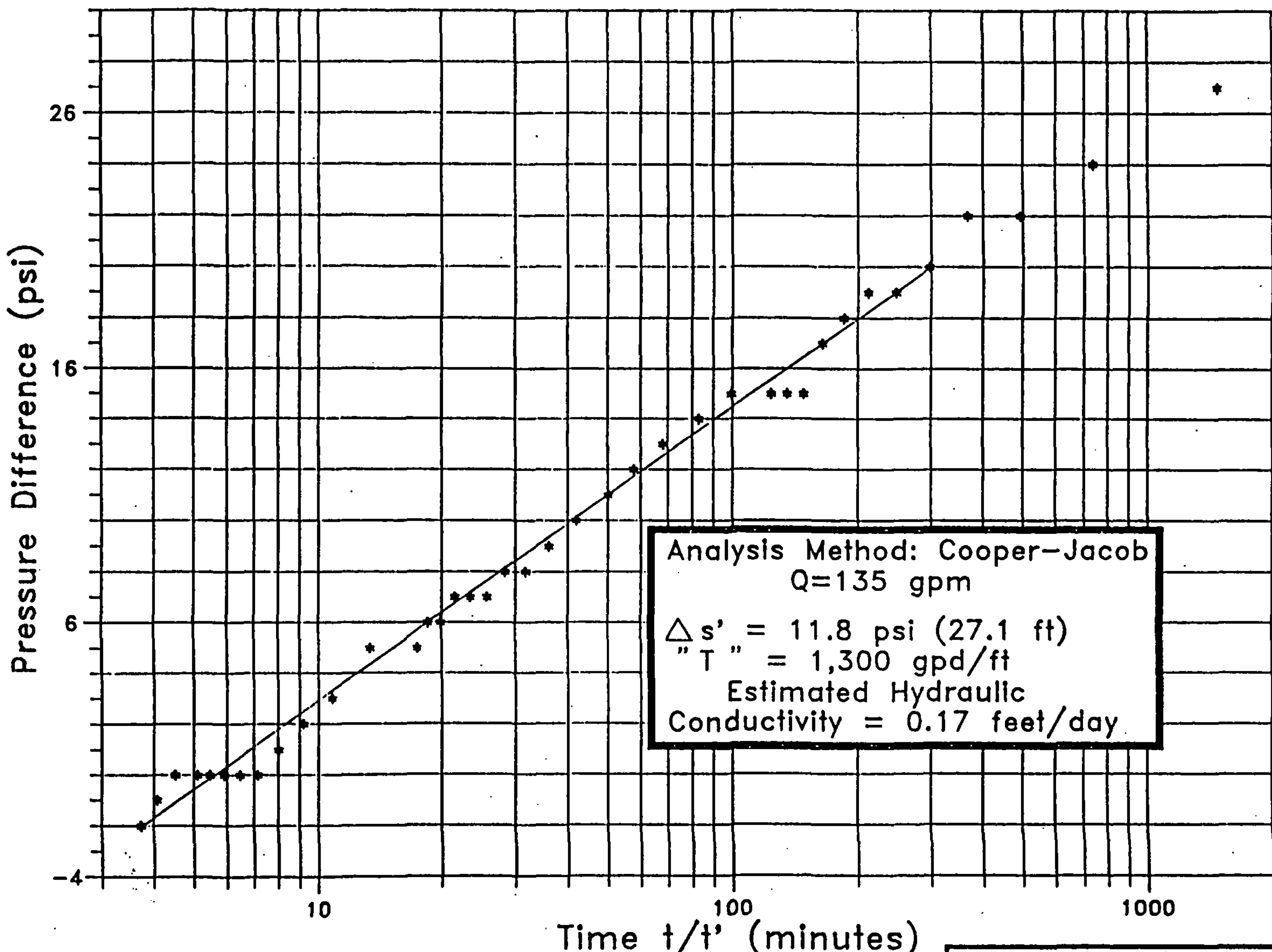
704 Hole Drawdown Test

DATE:	03/05/93
DESIGNED:	ROW
CHECKED:	RGB
APPROVED:	
DRAWN:	RJJ
PROJ.:	187112251

simon HYDRO-SEARCH

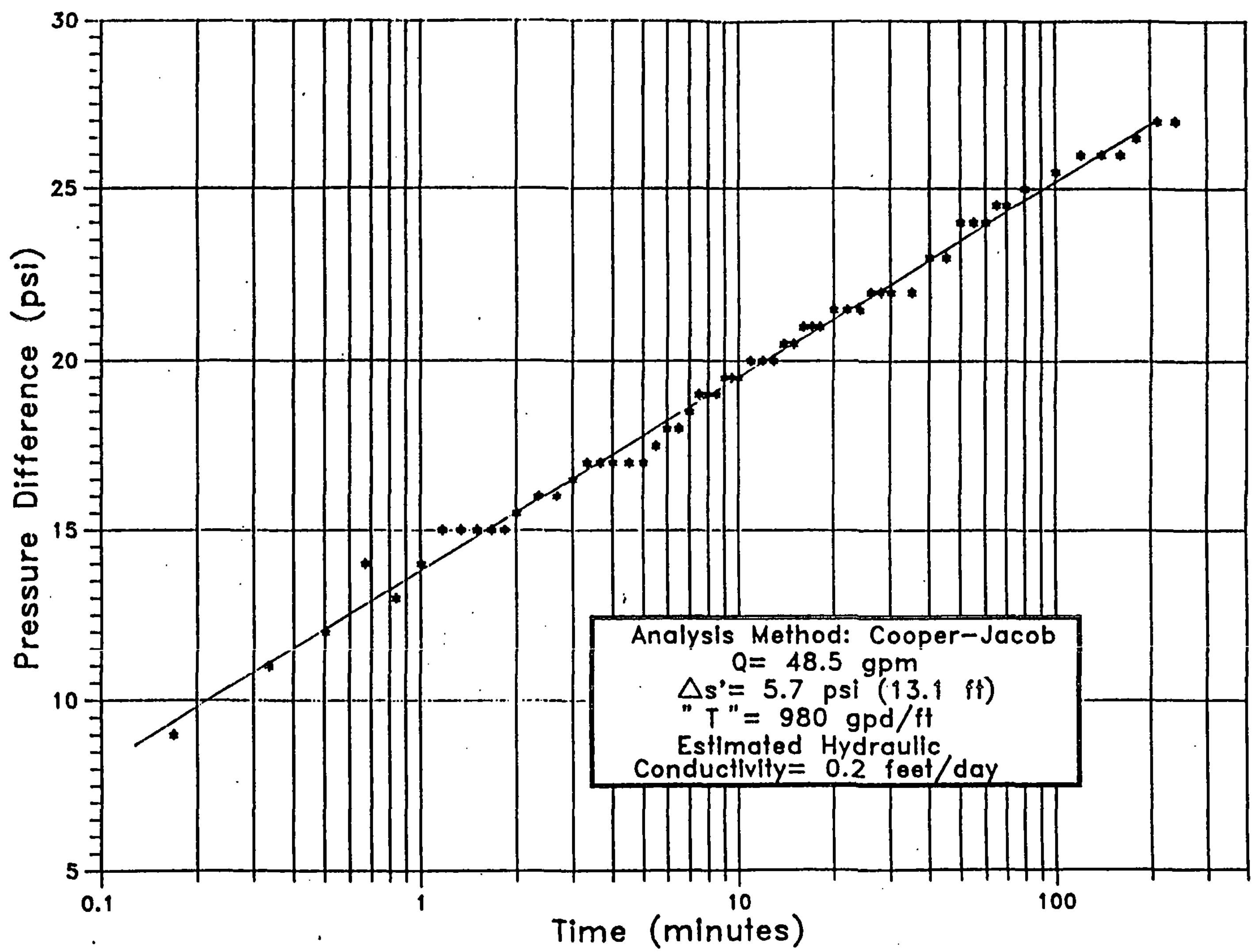
Figure A-4

/usr4/sunnysde/18711225/187gr004.DVG

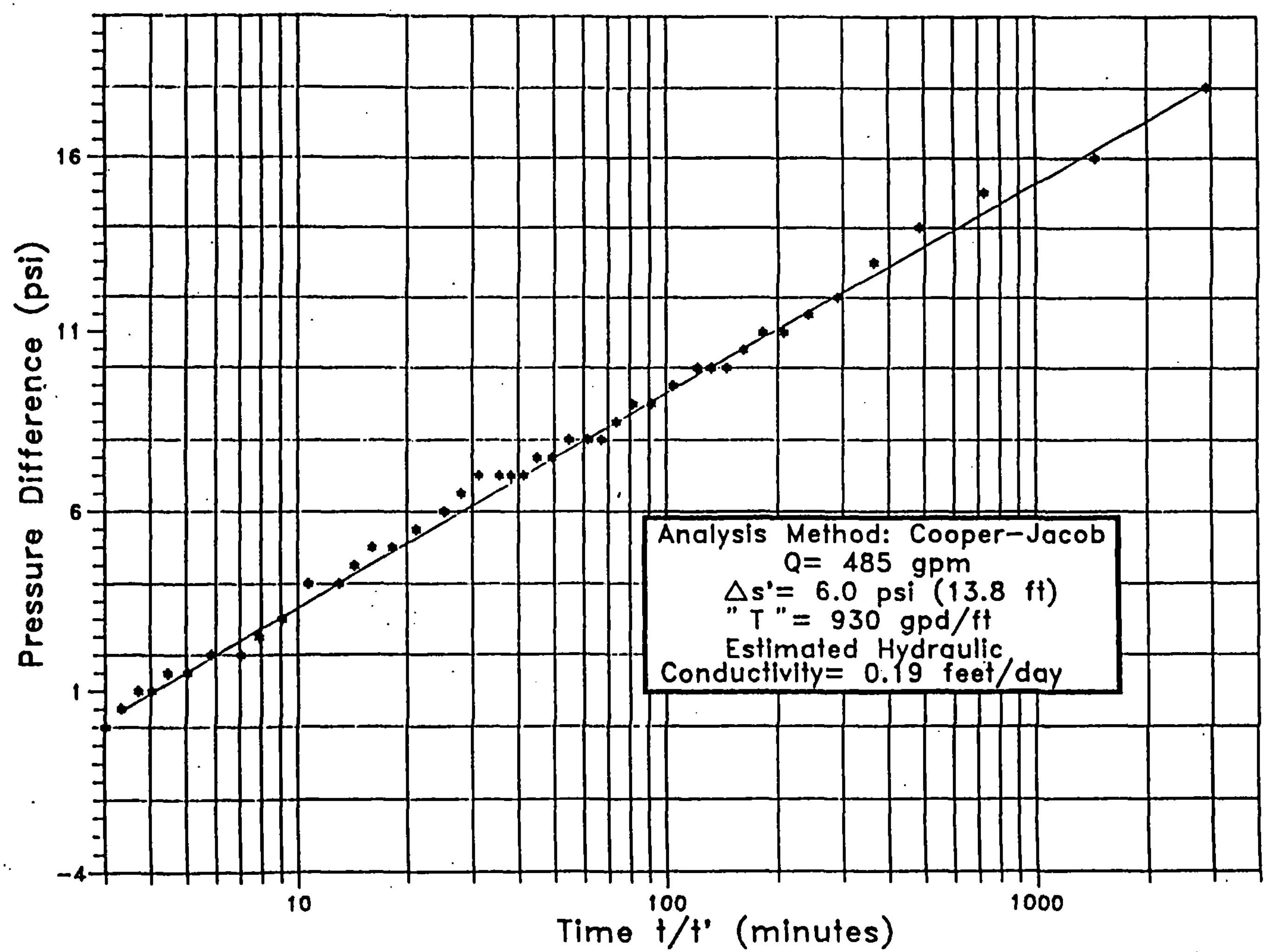


Sunnyside Gold Corporation San Juan County, Colorado	DATE: 03/06/93
	DESIGNED: ROW
704 Hole Recovery Test	CHECKED: RGB
	APPROVED:
	DRAWN: RAS
	PROJ.: 187112251
SIMON HYDRO-SEARCH	Figure A-5

/usr4/sunnysde/18711225/187gr-005.DWG



Sunnyside Gold Corporation San Juan County, Colorado	DATE: 03/05/93
781 Hole Drawdown Test	DESIGNED: ROW CHECKED: RGB APPROVED: DRAWN: RJJ PROJ.: 187112251
SIMON HYDRO-SEARCH	Figure A-6



Sunnyside Gold Corporation San Juan County, Colorado	DATE: 03/08/93
	DESIGNED: ROW
781 Hole Recovery Test	CHECKED: RGB
	APPROVED:
	DRAWN: RAS
	PROJ.: 187112251
SIMON HYDRO-SEARCH	Figure A-7

APPENDIX B

Volume of Sunnyside Mine Workings

SUNNYSIDE GOLD CORPORATION
AN ECHO BAY COMPANY

P.O. Box 177 • Silverton, CO 81433
Phone (303) 387-5533 • Telecopy (303) 387-5310

RECEIVED
JAN 19 1993

January 13, 1993

Mark D. Stock, Hydrogeologist
Simon Hydro-Search
5250 South Virginia Street
Reno, Nevada 89502

Dear Mark,

Per your request, please find attached the calculation for mined volumes at Sunnyside Mine. The calculation starts at the lowest workings of the mine, American Tunnel level, and is calculated at 100 foot elevations starting at 10,700 feet, for open workings below that elevation. The calculation stops at 12,210 feet or the elevation of the surface diversion ditch around the former Lake Emma.

The 80 scale engineering vein sections were used as a base source of information for the calculations. The area was calculated using a planimeter. The area was multiplied by average widths from geologic mapping and engineering measurements where available. When no width information was available, the stope widths were extrapolated from adjacent stopes. The volumes listed are cubic feet.

Cut and fill stopes in which waste rock was used for fill, calculated volume was multiplied by a 50% factor to allow for the volume consumed by fill.

Flat lying vein systems were mathematically corrected in order to reflect true volumes.

The waste drift volumes were calculated from horizontal measurements on 200 scale engineering plans and multiplied by average drift profiles on each level. Miscellaneous volumes such as shops, cutouts and hoistrooms were added to this calculation. The volumes listed are cubic feet.

The volumes are summarized by vein section or drifts for volume necessary to reach the elevation listed. There are also summaries for cumulative cubic feet to reach elevation, gallons added per 100 feet increase in elevation and cumulative gallons necessary to reach an elevation.

If you need additional information please call.

Sincerely,

William B. Goodhard

cc: Larry Perino

SUNNYSIDE GOLD CORPORATION
SUNNYSIDE MINE
WATER VOLUMES BY ELEVATION (cu.ft.)

	ELEVATION															
VEIN SECTION	10660 to 10700	10700 to 10800	10800 to 10900	10900 to 11000	11000 to 11100	11100 to 11200	11200 to 11300	11300 to 11400	11400 to 11500	11500 to 11600	11600 to 11700	11700 to 11800	11800 to 11900	11900 to 12000	12000 to 12100	121 to 122
1900	0	0	0	0	0	40,960	512	136,192	152,320	528,640	465,920	483,840	98,560	0	0	
LITTLE MARY	0	0	0	0	0	0	0	97,920	282,240	282,810	1,111,040	816,000	647,680	232,128	151,168	24,5
SUNNYSIDE	0	0	0	0	0	0	0	0	0	92,700	504,440	169,200	616,640	294,560	412,880	549,1
WASHINGTON	308,040	2,448,320	2,679,120	1,793,120	1,280,040	881,640	1,403,200	773,440	1,864,000	1,391,920	2,119,200	1,900,800	1,908,800	1,777,600	1,206,400	919,
BELLE CREOLE	110,880	355,040	381,360	280,448	184,880	132,400	53,520	86,800	251,440	261,520	597,760	421,280	429,040	521,200	398,840	195,
2150 FOOTWALL	0	0	0	0	0	60,800	492,160	539,760	1,657,952	1,140,608	2,394,160	998,800	964,160	746,400	568,800	
2150 EXT	0	0	0	0	0	0	230,300	423,000	1,187,500	1,211,000	675,600	241,280	0	0	0	
2150 HANGING WALL	0	0	0	0	0	0	0	5,600	389,120	546,380	486,240	403,280	32,400	0	0	
SPUR	0	0	0	0	0	0	0	0	0	124,840	915,370	534,300	1,048,704	750,400	407,104	178,
SPUR SPLIT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	116,320	138,
SPUR WEST	0	0	0	0	0	0	0	186,300	253,600	95,280	0	0	0	0	0	
2250	0	0	0	0	0	0	0	25,920	124,488	109,738	314,665	196,880	245,280	67,200	0	
MOUNTAIN SHEEP	0	0	0	0	0	0	0	40,320	120,960	11,200	0	0	0	0	0	
PORTLAND FW EAST	0	0	0	0	0	0	0	76,028	214,177	300,721	285,378	37,200	105,152	0	0	
PORTLAND FW WEST	0	0	0	0	0	0	0	0	319,336	375,558	135,764	0	0	0	0	
PORTLAND BX EAST	0	0	0	0	0	0	55,152	347,898	342,046	223,132	85,367	19,200	0	0	0	
PORTLAND BX WEST	0	0	0	0	0	0	96,000	272,668	671,882	312,275	0	0	0	0	0	
JOKER	0	0	0	0	0	0	0	0	0	0	0	0	82,950	0	0	10,
NO NAME	0	0	0	0	0	0	0	0	0	73,200	930,290	573,440	234,880	10,720	5,600	325,
DRIFTS AND MISC	1,012,960	0	0	0	0	0	98,000	898,530	0	1,083,060	67,412	1,264,617	137,520	0	236,360	127,
TOTAL	1,431,880	2,803,360	3,060,480	2,073,568	1,464,920	1,115,800	2,428,844	3,910,376	7,831,061	8,164,582	11,088,606	8,060,117	6,551,766	4,400,208	3,503,472	2,469

SUNNYSIDE GOLD CORPORATION
SUNNYSIDE MINE
WATER VOLUMES BY ELEVATION (cu.ft.)

CUMMULATIVE VOLUME (cu.ft.) TO FILL TO ELEVATION LISTED

VEIN SECTION	10700	10800	10900	11000	11100	11200	11300	11400	11500	11600	11700	11800	11900	12000	12100	122
1900	0	0	0	0	0	40,960	41,472	177,664	329,984	858,624	1,324,544	1,808,384	1,906,944	1,906,944	1,906,944	1,906,9
LITTLE MARY	0	0	0	0	0	0	0	97,920	380,160	662,970	1,774,010	2,590,010	3,237,690	3,469,818	3,620,986	3,645,5
SUNNYSIDE	0	0	0	0	0	0	0	0	0	92,700	597,140	766,340	1,382,980	1,677,540	2,090,420	2,639,5
WASHINGTON	308,040	2,756,360	5,435,480	7,228,600	8,508,640	9,390,280	10,793,480	11,566,920	13,430,920	14,822,840	16,942,040	18,842,840	20,751,640	22,529,240	23,735,640	24,655,2
BELLE CREOLE	110,880	465,920	847,280	1,127,728	1,312,608	1,445,008	1,498,528	1,585,328	1,836,768	2,098,288	2,696,048	3,117,328	3,546,368	4,067,568	4,466,408	4,662,1
2150 FOOTWALL	0	0	0	0	0	60,800	552,960	1,092,720	2,750,672	3,891,280	6,285,440	7,284,240	8,248,400	8,994,800	9,563,600	9,563,6
2150 EXT	0	0	0	0	0	0	230,300	653,300	1,840,800	3,051,800	3,727,400	3,968,680	3,968,680	3,968,680	3,968,680	3,968,6
2150 HANGING WALL	0	0	0	0	0	0	0	5,600	394,720	941,100	1,427,340	1,830,620	1,863,020	1,863,020	1,863,020	1,863,0
SPUR	0	0	0	0	0	0	0	0	0	124,840	1,040,210	1,574,510	2,623,214	3,373,614	3,780,718	3,958,8
SPUR SPLIT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	116,320	254,5
SPUR WEST	0	0	0	0	0	0	0	186,300	439,900	535,180	535,180	535,180	535,180	535,180	535,180	535,1
2250	0	0	0	0	0	0	0	25,920	150,408	260,146	574,811	771,691	1,016,971	1,084,171	1,084,171	1,084,1
MOUNTAIN SHEEP	0	0	0	0	0	0	0	40,320	161,280	172,480	172,480	172,480	172,480	172,480	172,480	172,
PORTLAND FW EAST	0	0	0	0	0	0	0	76,028	290,205	590,926	876,304	913,504	1,018,656	1,018,656	1,018,656	1,018,
PORTLAND FW WEST	0	0	0	0	0	0	0	0	319,336	694,894	830,658	830,658	830,658	830,658	830,658	830,
PORTLAND BX EAST	0	0	0	0	0	0	55,152	403,050	745,096	968,228	1,053,595	1,072,795	1,072,795	1,072,795	1,072,795	1,072,
PORTLAND BX WEST	0	0	0	0	0	0	96,000	368,668	1,040,550	1,352,825	1,352,825	1,352,825	1,352,825	1,352,825	1,352,825	1,352,
JOKER	0	0	0	0	0	0	0	0	0	0	0	0	82,950	82,950	82,950	93,
NO NAME	0	0	0	0	0	0	0	0	0	73,200	1,003,490	1,576,930	1,811,810	1,822,530	1,828,130	2,153,
DRIFTS AND MISC	1,012,960	1,012,960	1,012,960	1,012,960	1,012,960	1,012,960	1,110,960	2,009,490	2,009,490	3,092,550	3,159,962	4,424,579	4,562,099	4,562,099	4,798,459	4,925,
TOTAL	1,431,880	4,235,240	7,295,720	9,369,288	10,834,208	11,950,008	14,378,852	18,289,228	26,120,289	34,284,871	45,373,477	53,433,594	59,985,360	64,385,568	67,883,040	70,358,

SUNNYSIDE GOLD CORPORATION
SUNNYSIDE MINE
WATER VOLUMES BY ELEVATION (...)

GALLONS OF WATER TO FILL TO ELEVATION LISTED

VEIN SECTION	10700	10800	10900	11000	11100	11200	11300	11400
1900	0	0	0	0	0	306,381	3,830	1,018,716
LITTLE MARY	0	0	0	0	0	0	0	732,442
SUNNYSIDE	0	0	0	0	0	0	0	0
WASHINGTON	2,304,139	18,313,434	20,039,818	13,412,538	9,574,699	6,594,667	10,495,936	5,785,331
BELLE CREOLE	829,382	2,655,699	2,852,573	2,097,751	1,382,902	990,352	400,330	649,264
2150 FOOTWALL	0	0	0	0	0	454,784	3,681,357	4,037,405
2150 EXT	0	0	0	0	0	0	1,722,644	3,164,040
2150 HANGING WALL	0	0	0	0	0	0	0	41,888
SPUR	0	0	0	0	0	0	0	0
SPUR SPLIT	0	0	0	0	0	0	0	0
SPUR WEST	0	0	0	0	0	0	0	1,393,524
2250	0	0	0	0	0	0	0	193,882
MOUNTAIN SHEEP	0	0	0	0	0	0	0	301,594
PORTLAND FW EAST	0	0	0	0	0	0	0	568,689
PORTLAND FW WEST	0	0	0	0	0	0	0	0
PORTLAND BX EAST	0	0	0	0	0	0	412,537	2,602,277
PORTLAND BX WEST	0	0	0	0	0	0	718,000	2,039,557
JOKER	0	0	0	0	0	0	0	0
NO NAME	0	0	0	0	0	0	0	0
DRIFTS AND MISC	7,576,941	0	0	0	0	0	733,040	6,721,004
TOTAL	10,710,462	20,969,133	22,892,390	15,510,289	10,957,602	8,346,184	18,167,753	29,249,612

VEIN SECTION	11500	11600	11700	11800	11900	12000	12100	12
1900	1,139,354	3,954,227	3,485,082	3,619,123	737,229	0	0	
LITTLE MARY	2,111,155	2,115,419	8,310,579	6,103,680	4,844,646	1,736,317	1,130,737	183,
SUNNYSIDE	0	693,396	3,773,211	1,265,616	4,612,467	2,203,309	3,088,342	4,107,
WASHINGTON	13,942,720	10,411,562	15,851,616	14,217,984	14,277,824	13,296,448	9,023,872	6,878,
BELLE CREOLE	1,880,771	1,956,170	4,471,245	3,151,174	3,209,219	3,898,576	2,983,323	1,464,
2150 FOOTWALL	12,401,481	8,531,748	17,908,317	7,471,024	7,211,917	5,583,072	4,254,624	
2150 EXT	8,822,500	9,058,280	5,053,488	1,804,774	0	0	0	
2150 HANGING WALL	2,910,618	4,086,922	3,637,075	3,016,534	242,352	0	0	
SPUR	0	933,803	6,846,968	3,996,564	7,844,306	5,612,932	3,045,138	1,332,
SPUR SPLIT	0	0	0	0	0	0	870,074	1,034,
SPUR WEST	1,896,928	712,694	0	0	0	0	0	
2250	931,170	820,840	2,353,694	1,472,662	1,834,694	502,656	0	
MOUNTAIN SHEEP	904,781	83,776	0	0	0	0	0	
PORTLAND FW EAST	1,602,044	2,249,393	2,134,627	278,256	786,537	0	0	
PORTLAND FW WEST	2,388,633	2,809,174	1,015,515	0	0	0	0	
PORTLAND BX EAST	2,558,504	1,669,027	638,545	143,616	0	0	0	
PORTLAND BX WEST	5,025,677	2,335,817	0	0	0	0	0	
JOKER	0	0	0	0	620,466	0	0	80,
NO NAME	0	547,536	6,958,569	4,289,331	1,756,902	80,186	41,888	2,436,
DRIFTS AND MISC	0	8,101,289	504,242	9,459,335	1,028,650	0	1,767,973	952,
TOTAL	58,576,336	61,071,073	82,942,773	60,289,675	49,007,210	32,913,556	26,205,971	18,470,

SUNNYSIDE GOLD CORPORATION
SUNNYSIDE MINE
CUMULATIVE WATER VOLUMES BY ELEVATION (gal.)

CUMULATIVE GALLONS OF WATER TO FILL TO ELEVATION LISTED
##

VEIN SECTION	10700	10800	10900	11000	11100	11200	11300	11400	11500	11600	11700	11800	11900	12000	12100	1[illegible]
1900	0	0	0	0	0	306,381	310,211	1,328,927	2,468,280	6,422,508	9,907,589	13,526,712	14,263,941	14,263,941	14,263,941	14,263[illegible]
LITTLE MARY	0	0	0	0	0	0	0	732,442	2,843,597	4,959,016	13,269,595	19,373,275	24,217,921	25,954,239	27,084,975	27,268,[illegible]
SUNNYSIDE	0	0	0	0	0	0	0	0	0	693,396	4,466,607	5,732,223	10,344,690	12,547,999	15,636,342	19,745[illegible]
WASHINGTON	2,304,139	20,617,573	40,657,390	54,069,928	63,644,627	70,239,294	80,735,230	86,520,562	100,463,282	110,874,843	126,726,459	140,944,443	155,222,267	168,518,715	177,542,587	184,421,[illegible]
BELLE CREOLE	829,382	3,485,082	6,337,654	8,435,405	9,818,308	10,808,660	11,208;989	11,858,253	13,739,025	15,695,194	20,166,439	23,317,613	26,526,833	30,425,409	33,408,732	34,873,[illegible]
2150 FOOTWALL	0	0	0	0	0	454,784	4,136,141	8,173,546	20,575,027	29,106,774	47,015,091	54,486,115	61,698,032	67,281,104	71,535,728	71,535,[illegible]
2150 EXT	0	0	0	0	0	0	1,722,644	4,886,684	13,769,184	22,827,464	27,880,952	29,685,726	29,685,726	29,685,726	29,685,726	29,685,[illegible]
2150 HANGING WALL	0	0	0	0	0	0	0	41,888	2,952,506	7,039,428	10,676,503	13,693,038	13,935,390	13,935,390	13,935,390	13,935,[illegible]
SPUR	0	0	0	0	0	0	0	0	0	933,803	7,780,771	11,777,335	19,621,641	25,234,633	28,279,771	29,612,[illegible]
SPUR SPLIT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	870,074	1,904,[illegible]
SPUR WEST	0	0	0	0	0	0	0	1,393,524	3,290,452	4,003,146	4,003,146	4,003,146	4,003,146	4,003,146	4,003,146	4,003,[illegible]
2250	0	0	0	0	0	0	0	193,882	1,125,052	1,945,892	4,299,586	5,772,249	7,606,943	8,109,599	8,109,599	8,109,[illegible]
MOUNTAIN SHEEP	0	0	0	0	0	0	0	301,594	1,206,374	1,290,150	1,290,150	1,290,150	1,290,150	1,290,150	1,290,150	1,290,[illegible]
PORTLAND FW EAST	0	0	0	0	0	0	0	568,689	2,170,733	4,420,126	6,554,754	6,833,010	7,619,547	7,619,547	7,619,547	7,619,[illegible]
PORTLAND FW WEST	0	0	0	0	0	0	0	0	2,388,633	5,197,807	6,213,322	6,213,322	6,213,322	6,213,322	6,213,322	6,213,[illegible]
PORTLAND BX EAST	0	0	0	0	0	0	412,537	3,014,814	5,573,318	7,242,345	7,880,891	8,024,507	8,024,507	8,024,507	8,024,507	8,024,[illegible]
PORTLAND BX WEST	0	0	0	0	0	0	718,080	2,757,637	7,783,314	10,119,131	10,119,131	10,119,131	10,119,131	10,119,131	10,119,131	10,119,[illegible]
JOKER	0	0	0	0	0	0	0	0	0	0	0	0	620,466	620,466	620,466	701,[illegible]
NO NAME	0	0	0	0	0	0	0	0	0	547,536	7,506,105	11,795,436	13,552,339	13,632,524	13,674,412	16,110,[illegible]
DRIFTS AND MISC	7,576,941	7,576,941	7,576,941	7,576,941	7,576,941	7,576,941	8,309,981	15,030,985	15,030,985	23,132,274	23,636,516	33,095,851	34,124,501	34,124,501	35,892,473	36,845,[illegible]
TOTAL	10,710,462	31,679,595	54,571,986	70,082,274	81,039,876	89,386,060	107,553,813	136,803,425	195,379,762	256,450,835	339,393,608	399,683,283	448,690,493	481,604,049	507,810,019	526,280,[illegible]

APPENDIX C

Details of Geochemical Modeling

C-1 AMERICAN TUNNEL

C-1.1 Overview

The installation of a bulkhead in the American Tunnel at Sunnyside Mine will impound water and flood the mine workings to an estimated equilibrium water level of 11,500 feet msl (see Section 3.3). As the water levels rise in the mine workings, water from the flooded workings is expected to begin to move through natural fracture systems to discharge zones along Cement Creek. A minor amount of water may also move around the bulkhead through country rock adjacent to the mine tunnel. Geochemical modeling was used to assess: 1) the nature of the water that would be impounded behind the proposed bulkhead, 2) what reactions, if any, may occur within country rock as water migrates around the bulkhead, 3) what reactions may impact the impounded water or the minerals along the migration path to the surface, and 4) the character of the water that eventually results from surface discharge.

Very little water from the workings above F-level drops to lower levels and exits through the American Tunnel. Water that currently discharges from the American Tunnel is ground water that enters the mine in response to the hydraulic gradient developed by dewatering the mine workings. The water that will be impounded by the American Tunnel bulkhead is expected to be similar to ground water which is currently flowing into the mine from fractures. It is further conceptualized that that water will eventually reach the ground surface and equilibrate with atmospheric gases, precipitating a suite of oversaturated minerals. Changes in mineral precipitates or fluid composition behind the bulkhead and along the flow paths will be discussed only qualitatively due to limitations in the model.

C-1.2 Data

Most of the analyses from the mine waters were restricted to metals of concern for environmental and permitting purposes. However, a total of 14 water samples collected upstream of the proposed bulkhead in the American Tunnel were analyzed for major ions, minor constituents, and trace elements. Of these, all but four were samples taken from the drainage ditch of the American Tunnel. One sample was taken at a spring in the Sunnyside Cross Cut (before mixing with other water had occurred), and three were taken from two drill holes (#778 and #781) that had been extended into the American Tunnel walls. Eight of the samples are from mine drifts and may be a mixture of ground water and oxygenated water trickling down stopes. Analyses of the waters are shown in Table A-1.

The drill holes extend hundreds of feet back into the country rock, intersect non-ore mineralized fractures and are uncased. These four samples collected from the drill holes appear to be the most representative of the ground water in the fractured volcanic rock surrounding the mine.

The drill hole waters are very similar in overall character. The field pH is essentially neutral at 7.3 to 7.5 and field measurements showed no dissolved oxygen. The dominant anions are sulfate and bicarbonate. Calcium is the dominant cation and there is a moderate dissolved metals load. Analytical ion balance for major elements was within one or two percent.

Iron and manganese concentrations are consistent among the waters from the drill holes, but zinc concentrations are quite variable. The waters are characterized by relatively high fluoride and strontium concentrations and low concentrations of lead and cadmium. Copper, mercury, arsenic, boron, gold, selenium and silver are all at or below detection limits for these elements.

Four analyses of total metals were also available for samples from each of the two bedrock drill holes. These showed consistent results with the whole water analyses for most metals. Zinc and manganese showed the greatest variation, varying from below detection to greater than 10 mg/l for each element.

C-1.3 American Tunnel Reference Water

This section describes MINTEQA2 simulations which were used to define the American Tunnel reference water. This reference water is the best characterization of the in-situ ground water that can be developed from the available analytic, geochemical, geologic and petrographic data. The geology, mineralogy, chemical analyses and geochemistry were integrated to define the best approximation of ground-water characteristics within the fractured volcanic bedrock around the

American Tunnel. Conceptually, this water collects behind the bulkhead, moves through the bedrock around the bulkhead, and moves through the natural fracture system. This water is expected to discharge to the surface, equilibrate with the atmosphere and potentially mix with surface drainage.

The water from drill hole #778 (also known as the 0700 North drill hole) was selected as the type analysis for major ion chemistry. This drill hole extends the furthest into the country rock and the water analyzed best represents an average from the greatest volume of rock. The analysis used was for the sample collected on 10/07/91. A second, recent sample, collected 01/04/93, demonstrates the overall consistency of the water chemistry with time. Both of these analyses are contained in Table A-1. The anion analyses from 10/07/91 for sulfate, bicarbonate and fluoride were used as input into MINTEQA2. The cation analyses used for model input were those for calcium, magnesium, sodium, aluminum and strontium. To ensure appropriate mineral and aqueous species assemblages were considered, potassium and chloride were included in the modeling analysis at 50% of the reported detection limit.

The metal concentrations used for defining the American Tunnel reference water were an average of the detections among the four total metal samples and the whole water sample. In each case, the model input concentrations were greater than that of the sample from drill hole 778. MINTEQA2 has the capability to calculate redox speciation for some elements. Three redox pairs were included in the model run, HS^-

$/SO_4^{=}$, Fe^{++}/Fe^{+++}, and Mn^{++}/Mn^{+++}, with the stipulation that they exhibit a common oxidation state. Because copper was at or below the detection limit for all samples from drill holes, the Cu^{+}/Cu^{++} redox pair was not included in the American Tunnel modeling.

An initial equilibration run of MINTEQA2 using field-measured pH and atmospheric equilibration with oxygen modeled oversaturation with respect to CO_2 and calcite. Based upon probable ground-water flow paths and petrographic data, it is geologically likely that the on-site ground water is at or near equilibrium with calcite, but probably not oversaturated.

This model run, and all subsequent model runs, assumed appropriate in-situ temperatures. The field pH, the bicarbonate concentration, and the oversaturation of the analytic composition of the water with respect to calcite are believed to be, in part, artifacts of sampling procedures. Ground water sampled at the 778 borehole is under approximately 10 atmospheres of pressure. The release of this pressure with a concomitant exsolution of CO_2 equilibrating the $P(CO_2)$ of the solution to atmospheric concentrations would reduce total inorganic carbon in the water, elevate the pH, and increase the apparent saturation with respect to calcite.

Inorganic carbon lost to CO_2 exsolution is irretrievably lost. For the system under consideration, however, the magnitude of such loss is believed insignificant.

MINTEQA2 was used to determine the $P(CO_2)$ (and therefore that pH) at which the analyzed water would be in equilibrium with calcite. The model indicates that in-situ pH under the assumed consideration of equilibrium (rather than oversaturation) with calcite is 7.18 rather than the field-measured value of 7.53.

Geologic and petrographic data indicate a ubiquitous occurrence of disseminated pyrite. It is postulated that the in-situ water is in equilibrium with pyrite. MINTEQA2 was iteratively used to identify that eH and pH combination under which both calcite and pyrite would be in equilibrium with ground water.

Since silica was not among the analytes for the early samples, MINTEQA2 was used to estimate the probable H_4SiO_4 concentrations. Silica should be considered because some silicate minerals serve as pH buffers. Petrography and mineralogy suggest quartz saturation is probable. The program was used to identify the silica concentration at which the sampled water would be in equilibrium with the mineral quartz. The subsequent laboratory analyses for silica in the 1993 sample from borehole #778 confirmed the MINTEQA2-modeled estimate.

The mineral apatite is commonly noted in the area. Since phosphate concentrations in the whole water-analyses were below detection limits, MINTEQA2 was used to identify the phosphate concentration that would be in equilibrium with the mineral hydroxyapatite. The modeled equilibrium concentration is well below the detection limit reported in the laboratory analysis and the non-detection of phosphate is, therefore, consistent with known country rock mineralogy. Model simulation results are shown in Table A-2. Table A-3 is a partial list of available minerals from the thermodynamic database with which the reference water is at, or nearly at, equilibrium. The saturation index for each mineral is given. Generally, a saturation index greater than zero indicates oversaturation with respect to that mineral and a saturation index of less than zero indicates undersaturation.

C-1.4 Verification of Model Results

The conceptual model is that ground water from the fractured volcanic bedrock is the principal source of mine drainage at the American Tunnel level. This conceptual model, and the modeled reference water characterization, can be tested against field and laboratory analyses to verify the validity of the assumptions. The laboratory analyses from mine drainage samples (Table A-1) are for water that has had the opportunity to partially equilibrate with the atmosphere and precipitate oversaturated minerals. These processes can be simulated with the program.

MINTEQA2 was used to identify the equilibrium state of the water under atmospheric conditions (i.e., $P(CO_2) = 0.00032$ atm and $P(O_2) = 0.21$ atm). Model-simulated equilibration of the water chemistry to the atmosphere (permitting precipitation to occur) produces the mineral assemblage and residual fluid chemistry shown in Table A-4. The total metals load has decreased significantly as insoluble metal oxides precipitate. It is also noted that the pH has increased during precipitation. The pH increase reflects the combined effects of precipitation and fluid degassing. Note that the calcite precipitated (Table A-4) only partially balances the reduction in $CO_3^{=}$ between the in-situ (Table A-2) and precipitated (Table A-4) cases. The balance is exsolved as CO_2 gas, thereby reducing hydrogen ion activity and raising pH. The laboratory values for pH from water from the mine workings (Tables A-1 and A-5) are a physical analog of this process and support model simulations.

Mine drainage samples from the shallower sections of the American Tunnel show pH declines rather than the increase identified in the previous MINTEQA2 run. This is the result of degassing prior to sample collection and the sequential precipitation of mineral assemblages as the solution equilibrates with the atmosphere, with no opportunity for the precipitated minerals to back react with the flowing water. This process can be simulated with MINTEQA2. The field pH of the reference water was 7.53 which, given the bicarbonate concentration, indicates oversaturation with atmospheric partial pressures of CO_2. The result of the $P(CO_2)$ decrease from formation conditions is an oversaturation with respect to calcite. If the water is permitted to degas and precipitate calcite at that point, and the remaining water is then oxidized to atmospheric $P(O_2)$, a lower pH (7.1) final solution is obtained and the final total metals load is higher. Table A-6 shows the precipitate totals and final water chemistry. Hence, the observed water chemistry in the American Tunnel drainage ditch is in part due to the loss of some buffering capacity caused by mineral precipitation prior to complete equilibration to atmospheric conditions.

C-1.5 Impounded Water Chemistry

The water that will flood the mine when the American Tunnel bulkhead is installed is the reference water described above. Its chemical characterization is provided in Table A-2. Equilibration with atmospheric gas concentrations would be expected initially as reference water from the country rock fills the plugged mine. The process of sequential precipitation, as reference water fills the mine, may occur. If this occurs, it would be similar to that previously described for drainage along the tunnel floor with one important difference. Whereas the mine drainage leaves the precipitated minerals behind, minerals and fluid within the flooded mine would remain in contact and could potentially react with each other, maintaining much of the original buffering capacity of the water. To the extent that the reference water entering the mine workings oxidizes, it will regain some ability to dissolve ore minerals it contacts. The impact of this on water quality will be discussed later in this Appendix.

C-1.6 Potential Reactions Along Flow Paths

The saturation states of the American Tunnel reference water (the water that is expected to flood the deeper levels of the Sunnyside Mine) are reported in Table A-3. The results confirm that the sampled water is at equilibrium with the country rock.

In addition to the fixed equilibrium state with quartz, calcite, and pyrite, the water is at or near equilibrium with respect to muscovite (petrographically as sericite), kaolinite and other clays, fluorite, hematite, magnetite, and diaspore. Each of these is described in regional geologic literature and/or in the petrographic descriptions for samples from the American Tunnel. Further, among the feldspars in the MINTEQA2 data base, the water is near equilibrium only with low albite and microcline. This is again consistent with the known mineralogy of the propylitized country rock. Two minerals in the zeolite group are indicated as being oversaturated: laumontite and leonhardite. While neither is petrographically identified, both are likely plagioclase alteration products of the fine-grained volcanic ground mass. The non-detection of phosphate in the analysis is consistent with known apatite in the country rock.

In addition to equilibrium conditions existing between the country rock and the water, the calculation shows the reference water to be at equilibrium or oversaturated with rhodochrosite ($MnCO_3$), as well as each of the sulfide minerals which comprise the vein ores: pyrite (defined), sphalerite and galena. The dissolved cadmium concentrations could represent equilibrium with either or both greenockite (sulfide) or otavite (carbonate).

Equilibrium also exists with gypsum, a common sulfate mineral in the altered country rock and mineralized veins at deeper levels. The reference water is at or near equilibrium with the carbonates of cadmium, manganese, iron and zinc. As with flow through the country rock mineral assemblage, the reference water would flow through ore bearing veins in the Sunnyside Mine area with virtually no reaction and no change in chemistry except possible precipitation. There would also be no tendency for this water to dissolve vein material, thereby enhancing migration. The equilibrium of this water in-situ with country rock and with vein mineralization is relevant so long as the oxidation state remains unchanged.

C-2 TERRY TUNNEL

C-2.1 Overview

The diversion of mine drainage from the Terry Tunnel into deeper levels of the mine workings and the installation of a bulkhead in the Terry Tunnel may impound water within the workings to elevations above the Terry Tunnel. Concerns regarding this proposed bulkhead include: 1) what is the character of the in-situ ground water, 2) what is the character of any impounded water, 3) what reactions may occur along flow paths, and 4) what is the eventual character of the water after it reaches the surface and equilibrates with atmospheric gas compositions.

C-2.2 Data

The chemical system associated the water produced from the Terry Tunnel is considerably less constrained than that for the American Tunnel. There are three whole water analyses that are from samples taken upstream of the discharge treatment facility at the Terry Tunnel portal. These are composite waters from the mine floor rather than water collected from any specific discharge point. There are no data at the Terry Tunnel level comparable to the drill hole data from the American Tunnel. Table A-7 contains the analyses of these three samples. No field data are available for these samples so neither sample-specific temperature nor field pH are available. There are a substantial number of records available, however, from samples collected for metals testing (Simon Hydro-Search, 1992) that can be used for guidance.

The three analyses for Terry Tunnel water are from the period of 06/11/91 through 07/11/91. During this period, the flow volume ranged from 1.8 to 0.33 million gallons per day (Simon Hydro-Search, 1992, Figure 8). The flow variations represent, in part, a mixing of ground water with melt of the snow pack and with early summer rains that enter the system through open workings. A comparison of the chemical analyses with the discharge rates does not show a simple dilutional variation. Rather, there is systematic variation with time among various groups of constituents that may represent temporal variation of reactions or their rates, in combination with dilution effects. The precise nature or relative contributions of the different effects cannot be isolated with the limited data set. For purposes of modeling the Terry Tunnel water, the analysis that corresponds to the lowest discharge volume was selected as the best available characterization of the system. This sample was collected 07/11/91. It is felt that the lowest flow is temporally more representative of the shallower workings and it is conservative in that it represents the highest concentrations over the period sampled. In addition, the water selected had the lowest pH of the three.

Data omissions in the Terry Tunnel analyses impact the interpretation. Two of the three analyses report no carbonate or bicarbonate. There is also a substantial charge imbalance (13-14%) for these two analyses and that imbalance shows a relative deficiency of anions. Water analyses from the American Tunnel levels of the Sunnyside mine show much better balance and show anion concentrations are in excess of cations. The latter is readily explained in that the cation contributions from the metals are not normally included in the ion balance calculation. An inclusion of the metals contribution in the Terry Tunnel water aggravates the imbalance. The single sample which does report inorganic carbon shows excellent charge balance (<1%).

An additional anomaly with respect to the Terry Tunnel analyses is that suspended solids range from 7 to 28 percent of the combined total of dissolved and suspended solids by the time laboratory analyses were run. This strongly suggests that considerable precipitate may have formed and that the water analyses in Table A-7 represent, to a significant degree, residual waters rather than the water that may be impounded by a bulkhead.

General water chemistry at the Terry Tunnel level is similar to American Tunnel water with some significant differences. Sulfate is again the dominant anion, but total concentrations are only a third to a quarter as high. Similarly, total dissolved solids are half or less. Inorganic carbon in the Terry Tunnel water is present in low concentrations or is under-reported. Calcium is the dominant cation, but is proportionally reduced with the sulfate concentration. Chloride and potassium levels are higher and strontium, fluoride, and sodium concentrations are comparable. Both proportionately and absolutely, the Terry Tunnel waters show higher concentrations of magnesium, iron, manganese, zinc, lead and copper. Analytic results are shown in Table A-7.

Typical field-measured pH values from late summer periods of low flow are from 6 to 6.5. Laboratory-measured pHs have dropped to as low as 3.3 for the whole water samples and values from 3.5 to 4.5 are common for metals-only samples. The pH decrease is associated with a high proportion of suspended solids believed to be hydrated metal oxides.

C-2.3 Terry Tunnel Reference Water

Establishing a probable character of the in-situ vadose water or the impounded water behind the Terry Tunnel bulkhead is more problematic than at the American tunnel level. There are fewer analyses available and those that are available are less consistent and less reliable. Inferences made from the data are less certain, but some can still be drawn.

The analytic composition for the sample collected 07/11/91 was used in a MINTEQA2 simulation in which pH was determined by atmospheric equilibration with CO_2 and the redox state, by atmospheric concentrations of O_2. As with the American Tunnel system, sufficient silica was modeled to bring the system near equilibrium with quartz.

The Cu^{+}/Cu^{++} redox pair was added for the Terry Tunnel modeling to reflect the analytical presence of copper.

The simulation results for the water and an abbreviated list of computed saturation indices for minerals of interest are shown in Table A-8. It is noted that the calculated pH of the water, 3.7, is fairly consistent with the laboratory value of 3.3, but well below the typical field value of 6.4. At the assumed gas activities and silica concentrations, the analysis remains oversaturated with respect to clay minerals, oxides and hydroxides of iron, manganese and magnesium, and is at or near saturation with a number of sulfates, including gypsum. The simulation also predicts an inorganic carbon concentration of 0.8 mg/l as bicarbonate (speciated as H_2CO_3).

This simulation, and the local geology and petrography, suggest that the total absence of inorganic carbon is unlikely. Calcite is a common alteration mineral associated with the regional propylization and it is also a common vein mineral in the upper portions of the rock sequence. In addition, rhodochrosite is a common vein mineral. The charge imbalance and the absence of measured inorganic carbon anion species are probably related. It should be noted that at field pH values, inorganic carbon would occur dominantly as bicarbonate. However, at pHs reported in the laboratory analyses, the dominant carbon species would be H_2CO_3.

The mineralogy of the suspended solids was not determined. Differences between total and dissolved metal loads suggest iron compounds are a major contributor and there are lesser contributions from zinc, manganese, cadmium and lead. The concentrations of dissolved cadmium and lead, and to a lesser degree manganese and zinc, are consistent with common carbonate concentrations. This suggests that carbonate precipitation is controlling the dissolved concentration of these metals through early precipitation. If a representative concentration for CO_3 of $4x10^{-8}$ mg/l is used as a fixed constraint for MINTEQA2, the model predicts an inorganic carbon concentration of 6.4 mg/l as bicarbonate. This bicarbonate concentration is directly comparable to the one Terry Tunnel sample with detected inorganic carbon. Table A-9 shows the results of this simulation and lists the minerals that are at or near saturation. The computed pH for this system is 7.0. This value is slightly higher than, but consistent with, field pHs collected during comparable periods of low flow in late summer and early fall (Simon Hydro-Search, 1992, Appendix C). Further, although the added carbonate does not eliminate the charge balance problem, it does help reduce it. The modeled inorganic carbon concentration is believed to be a minimum likely value for vadose water entering the mine workings at the Terry Tunnel level and above.

The disparity between field and laboratory measurements for pH for the Terry Tunnel discharge waters and the strong precipitate formation are a clear indication that the water is not at equilibrium when sampled. That disequilibrium is largely a transient condition as a flow of reduced vadose water equilibrates with atmospheric concentrations of oxygen. Terry Tunnel discharge water appears to be a mix of reduced vadose water and oxygenated surface water that enters the mine workings.

During periods of low flow, a high proportion of vadose water to surface water should exist. The water sample from 07/11/91, a low flow period, with restored inorganic carbon concentrations, was considered over an oxidation range from pE = 18 to pE = -3. This corresponds to the range from atmospheric concentrations of oxygen to a reduced state slightly lower than that modeled for the water from the American Tunnel level. When saturation indices for various minerals that could serve as sources for the analyzed total metals are plotted as a function of pE, it is observed that the minerals pyrite, galena, sphalerite and chalcopyrite are each in equilibrium with the analytic composition of the water at essentially the same oxidation state, about pE = -1.5. These minerals are the most abundant ore minerals for iron, lead, zinc and copper.

If the total concentration for each of these metals is the result of leaching as surface water runs along open faces of the mine workings in contact with minerals, it is a remarkable coincidence that the concentrations reflect common saturation at a single redox value. Alternatively, if the individual concentrations reflect an unsaturated flow composition that formed in common contact with all the minerals under a closed, *reduced system, then the common pE at saturation would be expected. Of the two* scenarios, the latter is believed the more likely. The metals concentrations (total) indicate that mine discharge at the Terry Tunnel during periods of low flow is predominantly comprised of vadose water that acquired its observed metals load in a reduced environment through the dissolution to equilibrium of the most abundant sulfide ore minerals.

Terry Tunnel reference water is defined as the analytical water from 07/11/91 with a calculated inorganic carbon, sufficient silica to approach quartz saturation and a pE consistent with vadose water in equilibrium with the principal ore minerals. Table A-10 represents the output of a model simulation of this water and includes an abbreviated list of mineral saturation indices.

C-2.4 Impounded Water Chemistry

Water chemistry behind the Terry Tunnel bulkhead should closely resemble the Terry Tunnel reference water. This water will be subject to seasonal dilution and oxygenation as surface water flows into the workings. The magnitude of this impact, however, should be limited by two mechanisms. First, active efforts are underway to divert surface water away from entry points to the mine workings, so the historical seasonal fluctuations should diminish. Second, the dilute, oxygenated surface water will come in contact with the sulfides and carbonates in the flooded workings and move quickly toward a composition and redox state similar to the Terry Tunnel reference water. Consequently, the impounded water behind the proposed Terry

Tunnel bulkhead is expected to be similar to the Terry Tunnel reference water as described in Table A-10.

The modeling Terry Tunnel reference water used total metals concentrations where available, but does not contain the full metals load of the vadose water that sources it, nor does it contain anionic constituents that have precipitated from it. Based upon the apparent carbonate equilibrium among some of the metals and upon the calculations of sequential precipitation from the American Tunnel system, it is likely that the Terry Tunnel water that was analyzed had already lost part of its buffering capacity prior to analysis. Although there is no better available water to consider in building a reference water for the Terry Tunnel, it should be emphasized that using this water is conservative because this water is probably more reactive than the water that will collect behind the bulkhead.

C-2.5 Potential Reactions Along Flow Paths

An examination of the saturation states of the minerals from Table A-10 permits a qualitative statement of rock-water reactions that may occur between seepage around the proposed Terry Tunnel bulkhead and the country rock. As modeled, the Terry Tunnel reference water is undersaturated with respect to calcite, but is oversaturated with respect to a number of clay minerals. The Terry Tunnel reference water is at or near saturation with gypsum, other sulfates and several carbonates. Dissolution of calcite is expected to be more than off-set by precipitation of other pore-filling materials. Aside from clay precipitation for example, common ion effects could readily cause gypsum to precipitate as calcite dissolves. The reference water for the Terry Tunnel is defined under relatively reduced conditions. To the extent that the impounded water may be seasonally diluted or partially oxygenated, it will retain some ability to dissolve certain ore minerals with which it comes in contact.

In the absence of surface drainage dilution, the impounded reference water is saturated with respect to sulfides in the vein systems. Migration along these paths toward the surface should not affect either the minerals or the water. Since the reference water is modeled as undersaturated with respect to rhodochrosite, some increase in dissolved manganese could occur. This would be accompanied by increased carbonate concentrations, a corresponding increase in buffering capacity, and a minor rise in pH.

C-3 MIXING OF WATERS

The discussions and modeling to this point have considered the American Tunnel and Terry Tunnel bulkheads as isolated systems. In spite of the efforts that will be undertaken to slow advective transport through the mine workings (by collapsing ore passes and shafts), mixing of the reference waters will probably occur. The final distribution and pattern of mixing cannot be predicted. However, some observations can be made and qualitative calculations performed.

Each reference water can be considered an end member, generally representative of the deepest and shallowest portions of the flooded workings. As with the reference waters, the shallower waters are likely to be the most diluted, least reduced and contain the highest metals concentrations. The deeper waters will represent more reduced conditions, have higher total dissolved mass, and have lower metals concentrations. Each reference water is essentially in equilibrium with the minerals of the migration path to the surface, so the nature of the mass transfer to the surface is largely a question of the relative amounts of each end member in the final mix. For purposes of considering the impacts of surface discharge, two mix ratios are considered: 4:1 and 1:1 (American Tunnel reference water to Terry Tunnel reference water).

The MINTEQA2 program cannot perform an equilibrium calculation that includes a redox prediction for a compositional mix of two redox waters. However, it is reasonable to assume that the oxidation state of the mix of two waters will lie within the range of the end members. Table A-11 shows the result of the 4:1 compositional mix before and after precipitation within the mine workings. The pE of the system was chosen as -2.2, which is proportionally closer to the American Tunnel water chemistry. Table A-12 shows the result of 1:1 composition mix and a pE of -1.8, intermediate between the two end members.

Although each end member is at saturation with the minerals associated with the mine workings and vein minerals, either mix is oversaturated with respect to a number of these and other minerals. In the model, if these minerals precipitate within the workings or along the migration path, both the concentration and total load of the metals delivered to the surface is reduced. Virtually all iron and manganese may precipitate. In the case of zinc, up to 73% can potentially be precipitated before the water reaches discharge at the surface. The precipitation of minerals from the mixing of two equilibrium solutions is one of the processes by which supergene enrichment can occur in sulfide mineral deposits, a physical analog of this calculation.

The program requires an assigned redox state in order to perform the calculation. Hence, the amount of precipitation is a function of the assigned redox state. For this reason, the modeling of surface discharge will be considered with the full metals load, not reduced by any precipitation within the workings or along the flow path. This is a conservative assumption, which will result in an estimate of metals load that may be somewhat high.

C-4 SURFACE WATER DISCHARGE

Eventually the waters backed up behind both the proposed American Tunnel bulkhead and the proposed Terry Tunnel bulkhead will reach the ground surface as seeps or springs issuing from natural fractures in the volcanic rocks. The result of that discharge will be the oxidation of dissolved metals and the precipitation of any over-saturated minerals. This process will result in less impact to streams than that of tunnel drainage because of the disseminated, distributed nature of the process. Since the water will be moving through porous media, it will move at a slower rate (and at a lower volume) than open flow through the mine system. It will also have the benefit of a larger surface area of gas exchange. This will result in water that equilibrates with the atmosphere while in contact with any early precipitates, permitting back reaction and full benefit of any buffering capacity of the system.

Table A-4 characterizes discharge water that would result from precipitation of the American Tunnel reference water in equilibrium with the atmosphere. Table A-13 shows the expected final water chemistry of the Terry Tunnel reference water, as well as the simulated precipitation after equilibration with the atmosphere. Table A-11 presents the composition of a 4:1 mix of American Tunnel water to Terry Tunnel water. This ratio is approximately representative of the present relative discharge of the two systems, excluding the spring run-off period of the Terry Tunnel.

Table A-12 is the 1:1 mix of the two reference waters discussed above. Tables A-14 and A-15 show the mixed waters after equilibration with the atmosphere and precipitation of all oversaturated minerals. It is important to remember that the simulations were based on the assumption that none of the metals load was precipitated enroute to the surface discharge.

The final waters are dilute of significant metals concentrations, have relatively low total dissolved solids and are relatively neutral with respect to pH. The modeled precipitates are those which are expected in settings like the iron "bogs" that naturally occur in the area. These bogs almost certainly represent the analogous system operating in nature.

C-5 MIXING WITH SURFACE WATER

The final step in the modeling is to consider the impact of the discharging ground water, after reaching equilibrium, on the chemistry of Cement Creek. For this effort, it was assumed that the most likely volume of discharging ground water subject to possible passage through the mine was 75 gpm. Evapotranspiration losses were not considered. The modeled chemistries of discharging waters are shown in Tables A-14 and A-15. The chemical characterizations shown in Table A-16 represent the water in Cement Creek above the mine during the two periods of highest and lowest flow from which samples were taken between 04/09/87 and 04/23/91 (Simon Hydro-Search, 1992, Appendix C). Also included in Table A-16 are the results of the modeled discharge waters after equilibrium with the atmosphere and precipitation of their minerals. The modeled discharge chemistry will have no deleterious effects on Cement Creek water during periods of either high or low flow. In all cases, the carbonate content in the discharged mix will tend to neutralize the acid character of the stream, raising the pH of the stream. The concentrations of metals are comparable among low flow, high flow and modeled waters. The natural waters carry somewhat more iron and manganese and somewhat less zinc, with the contrast greater at periods of high flow. The iron and manganese concentrations are probably attributable to some combination of the lower pH in the stream, disequilibrium due to the kinetics of oxide precipitation, and/or poorly filtered suspended load from the stream waters.

Table A-1. Water analyses from deeper portions of the American Tunnel

		[illegible]ce	Flow MGD	Field pH	Field Conduct	Field Temp deg-C	Lab pH	Lab Conduct	TDS	TSS
West-drift	03/05/91	floor					6.71	1740	1670	56
Wash-fw	03/05/91	floor					7.24	1850	1700	1
Wash-hw	03/05/91	floor					7.54	1850	1710	<1
Wash-hw	03/13/91	floor					7.17	1990	1650	2
2195-op	03/05/91	floor					2.86	63200	7710	8
SS-drift	03/05/91	floor					7.60	1340	1140	1
SS-drift	03/13/91	floor					7.18	1430	1130	1
SS-xcut	01/04/93	spring					6.80	2070	1880	7
AT-7350	07/23/92	ditch	0.93	6.45	1850	14	6.50	1770	1610	38
DH-781	10/07/91	pipe		7.32	1140	13	7.06	1540	1360	6
DH-778	10/07/91	pipe		7.54	1200	12.8	6.39	1610	1420	63
DH-778	01/04/93	pipe					7.50	1810	1600	4
AT-6400	07/23/92	ditch	1.30	6.68	1880	13.3	6.69	1750	1650	36
AT-6400	01/31/92	ditch	1.34	7.93	1740	13.7	7.01	1970	1670	14

SIMON HYDRO-SEARCH

Table A–1. Water analyses from deeper portions of the American Tunnel, Con't.

Location	Major Anions Sulfate	Bicarb	Fluoride	Chloride	Major Cations Ca	Na	Mg	Sr	Al	K	Si
West–drift	1150	62.8	7.08	4.08	434	5.9	38.2	4.68	0.5	0.81	
Wash–fw	1130	163.0	4.19	4.08	430	6.2	47.7	3.99	0.2	1.44	
Wash–hw	1220	79.3	2.47	4.08	310	14.8	121.0	7.54	<.1	1.17	
Wash–hw	1230	73.2	2.27	2.04	174	15.0	198.0	7.29	<.1	1.11	
2195–op	5550	0.0	2.47	9.19	1860	9.8	285.0	3.62	101	2.09	
SS–drift	769	100.0	2.39	3.06	267	12.9	40.4	6.03	<.1	1.13	
SS–drift	766	98.2	1.79	1.02	252	11.9	52.1	5.78	<.1	1.05	
SS–xcut	1290	94.0	1.95	1.30	430	40.0	65.0	12.80	0.3	1.30	8.9
AT–7350	1200	31.7	4.82	0.51	363	8.8	18.1	6.79	1.3	0.50	
DH–781	905	102.0	1.33	<0.1	390	4.6	6.2	4.99	0.8	<.1	
DH–778	925	153.0	2.97	<0.1	414	3.0	4.0	3.78	0.6	<.1	
DH–778	1100	104.0	0.92	1.30	400	6.3	44.0	13.70	0.1	0.40	>3.7
AT–6400	1210	54.3	4.08	3.60	379	7.6	15.1	7.09	1.5	0.39	
AT–6400	1110	92.1	2.87	1.64	495	7.3	6.0	9.28		0.64	

Table A-1. Water analyses from deeper portions of the American Tunnel, Con't.

Location	Metals Iron (Diss)	Iron (Total)	Mn (Diss)	Mn (Total)	Zinc (Diss)	Zinc (Total)	Lead (Diss)	Lead (Total)	Cadmium (Diss)	Cadmium (Total)
West-drift	5.47	15.50	17.70	18.65	17.90	16.70	<.005	0.24	0.082	0.106
Wash-fw	<.05	0.38	61.90	64.29	34.30	33.43	<.005	0.21	0.073	0.090
Wash-hw	0.07	0.17	2.01	1.58	0.75	0.59	<.005	0.19	0.005	0.005
Wash-hw	0.06	0.22	2.21	2.18	0.98	0.95	<.005	0.15	<.002	0.002
2195-op	192.00		946.00		701.00		1.53		2.065	
SS-drift	0.14	0.25	2.10	1.83	0.09	0.09	<.005	0.18	0.003	0.000
SS-drift	<.05	0.18	1.87	1.94	0.06	0.07	<.005	0.08	<.002	0.004
SS-xcut	2.56	2.68	15.10	15.30	5.38	5.36	<.005	<.005	<.002	0.002
AT-7350	1.99		35.20		29.00		0.06		0.123	
DH-781	<.05		1.17		0.05		0.02		<.002	
DH-778	1.59		6.91		4.25		<.02		0.030	
DH-778	<.05	0.13	1.21	1.25	<.01	<.01	<.005	<.005	<.002	<.002
AT-6400	4.87		25.70		21.20		0.05		0.076	
AT-6400	0.17	6.62	11.2	11.33	7.84	7.8	0.04	0.12	0.030	0.047

Table A–1. Water analyses from deeper portions of the American Tunnel, Con't.

Location	Metals (con't) Copper (Diss)	Copper (Total)	Mercury (Diss)	Mercury (Total)	Arsenic (Diss)	Boron (Diss)	Chromium (Diss)	Gold (Diss)	Selenium (Diss)	Silver (Diss)
West–drift	<.01	0.21	<.001		<.005	<.05	<.02	<.05	<.005	<.01
Wash–fw	<.01	0.13	<.001		<.005	0.060	<.02	<.05	<.005	<.01
Wash–hw	<.01	0.03	<.001		<.005	0.060	<.02	<.05	<.005	<.01
Wash–hw	<.01	0.02	<.001		<.005	0.050	<.02	<.05	<.005	<.01
2195–op	24.80		<.001		0.036	<.01	<.02	<.05	<.005	<.01
SS–drift	<.01	0.02	<.001		<.005	0.060	<.02	<.05	<.005	<.01
SS–drift	<.01	<.01	<.001		<.005	0.030	<.02	<.05	<.005	<.01
SS–xcut	0.01	0.01	<.001	<.001	0.005		<.02	0.030	<.005	0.020
AT–7350	0.66		<.001		0.005	0.060	0.170	<.05	<.005	<.01
DH–781	<.01		<.001		<.005	<.01	<.02	<.05	<.005	<.01
DH–778	<.01		<.001		<.005	<.01	<.02	0.060	<.005	<.01
DH–778	0.01	0.01	<.001	<.001	<.005		<.02	0.005	<.005	0.030
AT–6400	0.79		<.001		0.007	0.090	0.150	<.05	<.005	<.01
AT–6400	<.01	0.13	<.002	<.002	<.005	<.01	<.02	0.120	<.005	0.040

Table A–2. American Tunnel reference water

Analyte	Concentration mg/L	Source	MINTEQA2 Component	Dominant Species
Sulfate	925	analysis	HS^-/SO_4^{--}	SO_4^{--}
Bicarbonate	150	analysis	CO_3^{--}	HCO_3^-
Chloride	0.05	1/2 detect lim	Cl^-	Cl^-
Fluoride	2.97	analysis	F^-	F^-
Phosphate	0.007	mineral equil	PO_4^{---}	HPO_4^{--}
Calcium	414	analysis	Ca^{++}	Ca^{++}
Magnesium	4.03	analysis	Mg^{++}	Mg^{++}
Sodium	2.99	analysis	Na^+	Na^+
Aluminum	0.6	analysis	Al^{+++}	$Al(OH)_3$ aq
Potassium	0.05	1/2 detect lim	K^+	K^+
Silica	5.93	mineral equil	H_4SiO_4	H_4SiO_4
Iron	2.75	comb. analysis	Fe^{++}/Fe^{+++}	Fe^{++}
Manganese	8.08	comb. analysis	Mn^{++}/Mn^{+++}	Mn^{++}
Zinc	5	comb. analysis	Zn^{++}	Zn^{++}
Strontium	3.78	analysis	Sr^{++}	Sr^{++}
Cadmium	0.04	comb. analysis	Cd^{++}	Cd^{++}
Lead	0.025	comb. analysis	Pb^{++}	$PbCO_3$ aq
pH	7.18	mineral equil	H^+	HCO_3^-
pE	−2.46	mineral equil	e^-	MnO_4^{--}

sunny\wp\traci\2251\A–2F.WK3

Table A-3. Saturation indices of selected minerals with respect to American Tunnel reference water

Mineral	Saturation Index	Type	
Greenockite	4.86	cadmium sulfide	
Galena	2.87	lead sulfide	
Sphalerite	2.65	zinc sulfide	
Pyrite	0.00	iron sulfide	
MnS green	−12.84	manganese sulfide	
Diaspore	3.48	aluminum oxide/hydroxide	
Boehmite	1.67	aluminum oxide/hydroxide	
Gibbsite	1.65	aluminum oxide/hydroxide	
Goethite	0.06	iron oxide/hydroxide	
$Al(OH)_3$	−0.10	aluminum oxide/hydroxide	
Magnetite	6.36	iron oxide (multiple)	
Hematite	5.08	iron oxide (multiple)	
Al_2O_3	−0.69	aluminum oxide (multiple)	
Fluorite	0.82	calcium fluoride	
Otavite	0.73	cadmium carbonate	
Rhodochrosite	0.10	manganese carbonate	
Calcite	0.00	calcium carbonate	
Siderite	−0.33	iron carbonate	
Smithsonite	−0.77	zinc carbonate	
Cerussite	−1.00	lead carbonate	
Strontianite	−1.44	strontium carbonate	
Dolomite	−1.88	Ca++/Mg++carbonate	
Alunite	2.52	potasium sulfate	
Gypsum	0.01	calcium sulfate	
Anhydrite	−0.33	calcium sulfate	
Celestite	−0.65	strontium sulfate	
Anglesite	−2.85	lead sulfate	
Fluorapatite	10.85	F−/Ca++ phosphate	
Hydroxyapatite	0.00	OH−/Ca++ phosphate	
Leonhardite	15.62	frame silicate	(zeolite)
Laumontite	1.34	frame silicate	(zeolite)
Quartz	0.00	frame silicate	
Microcline	−1.28	frame silicate	(feldspar)
Albite (low)	−1.41	frame silicate	(feldspar)
Nontronites	13.16	sheet silicate	(clay)
(Ca, Mg, Na, K)	5.86	sheet silicate	(clay)
Kaolinite	7.02	sheet silicate	(clay)
Montmorillonite	5.50	sheet silicate	(clay)
Muscovite	7.13	sheet silicate	(mica)
Pyrophyllite	7.07	sheet silicate	(mica)

TABLE A–4

AMERICAN TUNNEL REFERENCE WATER
After Equilibration to Atmosphere and Precipitation
(THESE ARE VALUES GENERATED BY THE MODEL)

MINTEQA2 Component	Concentration mol/L	mg/L	Dominant Species
SO_4^{--}	9.644E–03	926	SO_4^{--}
CO_3^{--}	5.66E–04	33.9	HCO_3^-
Cl–	1.412E–06	0.05	Cl–
F–	5.856E–05	1.11	F–
Ca++	8.396E–03	337	Ca++
Mg++	1.660E–04	4.04	Mg++
Na+	1.303E–04	3.00	Na+
Al+++	6.181E–09	ND	$Al(OH)_3$ aq
K+	1.281E–06	0.05	K+
H_4SiO_4	1.238E–07	ND	H_4SiO_4
Fe+++	2.486E–15	ND	$Fe(OH)_2^+$
Mn++	2.619E–16	ND	Mn++
Zn++	1.493E–05	0.97	Zn++
Sr++	4.321E–05	3.79	Sr++
Cd++	5.344E–08	0.006	Cd++
Pb++	1.208E–07	0.025	$PbCO_3$ aq
pH	7.87		
pE	13.81		

Precipitated Minerals:	moles precipitated per liter of solution	mg precipitated per liter of solution	Minerals near saturation:	S.I.
Calcite	1.91E–03	191.171	Gypsum	–0.04
Pyrolusite	1.47E–04	12.780	Anhydrite	–0.38
$ZnSiO_3$	6.17E–05	8.728	Celestite	–0.60
Fluorite	4.90E–05	3.826	Cerussite	–0.99
Hematite	2.47E–05	3.944	Strontianite	–1.33
Diaspore	2.23E–05	1.338	Smithsonite	–1.39
Otavite	3.03E–07	0.052		

Table A–5. Water analyses from shallower portions of the American Tunnel

Location	Date	Source	Flow MGD	Field pH	Field Conduct	Field Temp deg–C	Lab pH	Lab Conduct	TDS	TSS
AT–3450	07/23/92	ditch	1.41	6.67	1900	12.9	6.36	1830	1660	48
Fault–1	03/05/91	seep		5.90			2.45	3030	2560	42
Fault–2	03/05/91	seep		6.05			2.49	3440	2890	46
AT–2700	07/23/92	ditch	1.90	6.43	1980	12.1	4.77	1820	1730	88
AT–2400	07/23/92	ditch	2.06	6.36	1990	12.1	4.7	1860	1740	90
AT–portal	07/23/92	flume	2.20	6.36	1930	11.7	5.18	1880	1720	84
AT–portal	01/31/92	flume	3.17	6.60	1780	11.5	5.78	1920	1750	67

Table A–5. Water analyses from shallower portions of the American Tunnel, Con't.

						Na	Mg	Sr	Al	K	Si
				[illegible]	379.0	7.6	16.3	6.68	0.5	1.40	
				0.50	42.5	13.6	163.0	5.59	12.8	1.50	
			[illegible].87	6.13	13.9	9.2	21.7	5.89	22.3	1.69	
			6.46	<.10	380.0	7.4	16.3	6.73	1.9	0.39	
		2.44	6.46	0.82	391.0	7.4	19.3	6.46	1.9	1.17	
	1300	7.93	5.94	1.03	385.0	7.8	19.3	6.49	1.8	0.39	
AT–portal	1230	15.90	5.04	1.75	496.0	7.0	12.7	8.48	0.9		

SIMON HYDRO-SEARCH

sunny\wp\traci\2251\A–5F.WK3

Table A–5. Water analyses from shallower portions of the American Tunnel, Con't.

Location	Metals Iron (Diss)	Iron (Total)	Mn (Diss)	Mn (Total)	Zinc (Diss)	Zinc (Total)	Lead (Diss)	Lead (Total)	Cadmium (Diss)	Cadmium (Total)
AT–3450	0.3		26.0		21.2		<.01		0.08	
Fault–1	360.0	344.0	101.0	91.4	62.4	47.08	<.005	0.21	0.03	0.06
Fault–2	537.0	531.0	151.0	132.6	92.1	70.1	0.43	0.59	0.09	0.11
AT–2700	15.0		28.8		20.9		<.01		0.07	
AT–2400	5.6		30.5		20.3		<.01		0.06	
AT–portal	10.5	36.2	25.7	29.2	18.7	20.6	<.01	0.05	0.07	0.07
AT–portal		39.7	16.1	18.6	8.1	10.3	0.03	0.05	0.02	0.03

Table A–5. Water analyses from shallower portions of the American Tunnel, Con't.

Location	Metals (con't.) Copper (Diss)	Copper (Total)	Mercury (Diss)	Mercury (Total)	Arsenic (Diss)	Boron (Diss)	Chromium (Diss)	Gold (Diss)	Selenium (Diss)	Silver (Diss)
AT–3450	0.18		<.001		<.005	0.12	0.13	<.05	0.005	<.01
Fault–1	<.01	0.34	<.001		<.005	<.01	<.02	<.05	<.005	<.01
Fault–2	<.01	0.03	<.001		<.005	<.01	<.02	<.05	<.005	<.01
AT–2700	0.33		<.001		<.005	0.13	0.16	<.05	<.005	<.01
AT–2400	0.29		<.001		<.005	0.16	0.14	<.05	<.005	<.01
AT–portal	0.23	0.82	<.001	<.001	<.005	0.15	0.17	<.05	<.005	<.01
AT–portal	0.04	0.07	<.002	<.002	<.005	<.01	<.02	0.12	<.005	<.01

TABLE A-6

AMERICAN TUNNEL REFERENCE WATER

CO_2 flashed, calcite precipitated, then equilibrated with the atmosphere and again precipitated

MINTEQA2 Component	Concentration mol/L	mg/L	Dominant Species
SO_4^{--}	9.644E-03	926	SO_4^{--}
CO_3^{--}	1.042E-04	6.25	HCO_3^-
Cl-	1.412E-06	0.05	Cl-
F-	5.539E-05	1.05	F-
Ca++	9.445E-03	379	Ca++
Mg++	1.660E-04	4.04	Mg++
Na+	1.303E-04	3.00	Na+
Al+++	5.480E-09	ND	$Al(OH)_3$ aq
K+	1.281E-06	0.05	K+
H_4SiO_4	8.160E-07	ND	H_4SiO_4
Fe+++	7.112E-15	ND	$Fe(OH)_2^+$
Mn++	9.213E-15	ND	Mn++
Zn++	7.085E-05	4.63	Zn++
Sr++	4.321E-05	3.79	Sr++
Cd++	3.564E-07	0.04	Cd++
Pb++	1.208E-07	0.025	$PbSO_4$ aq
pH	7.09		
pE	14.56		

Precipitated Minerals:	moles	mg	Minerals near saturation:	S.I.
Calcite *	8.515E-04	85.23	Gypsum	-0.01
Pyrolusite	1.473E-04	12.81	Anhydrite	-0.34
Ca-Nontronite	1.581E-05	6.71	Mg-Nontronite	-0.59
Fluorite	5.061E-05	3.95	Celestite	-0.62
Hematite	8.845E-06	1.41	Calcite	-1.50
Diaspore	1.888E-05	1.13	Otavite	-0.68
$ZnSiO_3$	2.934E-06	0.42	Cerussite	-1.81
			Smithsonite	-2.21
			Strontianite	-2.89

* precipitated in earlier step

sunny\wp\traci\2251\A-6F.WK3

SIMON HYDRO-SEARCH

Table A-7. Water analyses from the Terry Tunnel

Location	Date	Source	Flow MGD	Field pH	Field Conduct	Field Temp deg-C	Lab pH	Lab Conduct	TDS	TSS
Influent	06/11/91	ditch	1.30	5.60		10.0	5.33	528	359	92
Influent	06/17/91	ditch	1.80	4.40		9.9	4.2	587	426	166
Influent	07/11/91	ditch	0.33	4.10			3.32	933	726	54

Location	Major Anions Sulfate	Bicarb	Fluoride	Chloride	Major Cations Ca	Na	Mg	Sr	Al	K	Si
Influent	264	3.05	2.37	1.42	55.7	1.5	33.9	0.56	0.9	1.14	
Influent	300	0.00	3.38	5.31	117.0	2.2	0.1	0.61	1.5	1.73	
Influent	544	0.00	5.56	0.30	160.0	1.7	19.0	0.98	3.2	1.20	

Location	Metals Iron (Diss)	Iron (Total)	Mn (Diss)	Mn (Total)	Zinc (Diss)	Zinc (Total)	Lead (Diss)	Lead (Total)	Cadmium (Diss)	Cadmium (Total)	Copper (Diss)	Copper (Total)
Influent	0.1		29.1		20.1	20.41	0.06	1.00	0.09	0.06	1.43	1.83
Influent	0.7		37.4		25.3		0.06		0.02		2.77	
Influent	4.1	13.2	76.8	77.8	47.3	47.6	0.88	1.05	0.19	0.19	5.05	5.11

Location	Metals (con't.) Mercury (Diss)	Mercury (Total)	Arsenic (Diss)	Boron (Diss)	Chromium (Diss)	Gold (Diss)	Selenium (Diss)	Silver (Diss)
Influent	<.0002	<.0002	<.002	<.05	<.02	<.05	<.002	<.01
Influent	<.0002		<.002	<.01	<.02	<.05	<.002	<.01
Influent	<.0002	<.0002	0.008	0.08	<.02	<.05	<.002	<.01

SIMON HYDRO-SEARCH

Table A–8. Terry Tunnel water equilibrated to atmospheric gas concentrations (This table gives the results of MINTEQA2 modeling.)

Analyte	*Concentration mg/L*	*Source*	*MINTEQA2 Component*	*Dominant Species*
Sulfate	544	analysis	HS^-/SO_4^{--}	SO_4^{--}
Bicarbonate	7.9	atmos equil	CO_3^{--}	H_2CO_3 aq
Chloride	0.3	analysis	Cl^-	Cl^-
Fluoride	5.56	analysis	F^-	AlF_3 aq
Calcium	160	analysis	Ca^{++}	Ca^{++}
Magnesium	19	analysis	Mg^{++}	Mg^{++}
Sodium	1.7	analysis	Na^+	Na^+
Aluminum	3.2	analysis	Al^{+++}	AlF^{++}
Potassium	1.2	analysis	K^+	K^+
Silica	5.3	mineral equil	H_4SiO_4	H_4SiO_4
Iron	13.24	analysis(total)	Fe^{++}/Fe^{+++}	$Fe(OH)_2^+$
Manganese	77.78	analysis(total)	Mn^{++}/Mn^{+++}	Mn^{++}
Copper	5.11	analysis(total)	Cu^+/Cu^{++}	Cu^{++}
Zinc	47.6	analysis(total)	Zn^{++}	Zn^{++}
Strontium	0.98	analysis(total)	Sr^{++}	Sr^{++}
Cadmium	0.19	analysis(total)	Cd^{++}	Cd^{++}
Lead	1.05	analysis(total)	Pb^{++}	Pb^{++}
pH	3.70	atmos equil	H^+	
pE	18.58	atmos equil	e^-	MnO_4^-

Nineral satu…tion indices			
Sates:		Fluorite	−1.39
tronites	18.28 to 10.97		
tz	0.06	Oxides/hydroxides:	
		Hematite	13.22
		Pyrolusite	4.69
	−0.48	Goethite	4.15
	−0.50	Magnetite	1.12
	−0.89	Manganite	−0.04
	−1.36	Diaspore	−3.55

sun

A–8F.WK3

Table A–9. Terry Tunnel water with restored inorganic carbon equilibrated to atmosphere
(This table gives the results of MINTEQA2 modeling.)

Analyte	Concentration mg/L	Source	MINTEQA2 Component	Dominant Species
Sulfate	544	analysis	HS^-/SO_4^{--}	SO_4^{--}
Bicarbonate	6.41	mineral equil	CO_3^{--}	HCO_3^-
Chloride	0.3	analysis	Cl^-	Cl^-
Fluoride	5.56	analysis	F^-	AlF_3 aq
Calcium	160	analysis	Ca^{++}	Ca^{++}
Magnesium	19	analysis	Mg^{++}	Mg^{++}
Sodium	1.7	analysis	Na^+	Na^+
Aluminum	3.2	analysis	Al^{+++}	AlF_3 aq
Potassium	1.2	analysis	K^+	K^+
Silica	5.3	mineral equil	H_4SiO_4	H_4SiO_4
Iron	13.24	analysis(total)	Fe^{++}/Fe^{+++}	$Fe(OH)_2^+$
Manganese	77.78	analysis(total)	Mn^{++}/Mn^{+++}	Mn^{++}
Copper	5.11	analysis(total)	Cu^+/Cu^{++}	Cu^{++}
Zinc	47.6	analysis(total)	Zn^{++}	Zn^{++}
Strontium	0.98	analysis(total)	Sr^{++}	Sr^{++}
Cadmium	0.19	analysis(total)	Cd^{++}	Cd^{++}
Lead	1.05	analysis(total)	Pb^{++}	$PbSO_4$ aq
pH	7.01	atmos equil		
pE	15.27	atmos equil		MnO_4^-

Mineral saturation indices			
Silicates:		Oxides/hydroxides:	
Nontronites	28.89 to 21.58	Hematite	20.36
Leonhardite	14.77	Magnetite	11.83
Muscovite	8.96	Pyrolusite	11.30
Montmorillonite	8.29	Goethite	7.72
Pyrophyllite	8.08	Manganite	6.57
Kaolinite	7.50	Diaspore	3.65
Microcline	0.18	Tenorite	0.87
Quartz	0.06		
		Carbonates:	
Sulfates:		Malachite	1.23
Brochantite	5.06	Otavite	−0.11
Gypsum	−0.47	Cerussite	−0.17
Anglesite	−0.58	Rhodochrosite	−0.53
Anhydrite	−0.89	Smithsonite	−1.38
Celestite	−1.35	Calcite	−2.00
Fluorite	−0.17		

sunny\wp\traci\2251\A–9F.WK3

Table A–10. Terry Tunnel reference water

Analyte	Concentration mg/L	Source	MINTEQA2 Component	Dominant Species
Sulfate	544	analysis	$HS-/SO_4--$	SO_4--
Bicarbonate	6.41	mineral equil	CO_3--	HCO_3-
Chloride	0.3	analysis	Cl–	Cl–
Fluoride	5.56	analysis	F–	AlF_3 aq
Calcium	160	analysis	Ca++	Ca++
Magnesium	19	analysis	Mg++	Mg++
Sodium	1.7	analysis	Na+	Na+
Aluminum	3.2	analysis	Al+++	AlF_3 aq
Potassium	1.2	analysis	K+	K+
Silica	5.3	mineral equil	H_4SiO_4	H_4SiO_4
Iron	13.24	analysis(total)	Fe++/Fe+++	Fe++
Manganese	77.78	analysis(total)	Mn++/Mn+++	Mn++
Copper	5.11	analysis(total)	Cu+/Cu++	Cu+
Zinc	47.6	analysis(total)	Zn++	Zn++
Strontium	0.98	analysis(total)	Sr++	Sr++
Cadmium	0.19	analysis(total)	Cd++	Cd++
Lead	1.05	analysis(total)	Pb++	Pb++
pH	7.01	atmos equil	H+	HCO_3-
pE	–1.50	mineral equil	e–	MnO_4-

Mineral saturation indices			
Silicates:		Oxides/hydroxides:	
Nontronites	15.11 to 7.80	Magnetite	7.93
Leonhardite	14.77	Cuprite	7.56
Muscovite	8.96	Hematite	6.58
Pyrophyllite	8.08	Diaspore	3.65
Montmorillonite	6.78	Gibbsite	1.84
Kaolinite	7.51	Goethite	0.83
Microcline	0.18		
Quartz	0.06		
		Carbonates:	
Sulfates:		Otavite	–0.11
Gypsum	–0.48	Cerussite	–0.17
Anglesite	–0.58	Rhodochrosite	–0.53
Anhydrite	–0.89	Smithsonite	–1.38
Celestite	–1.35	Calcite	–2.00
Fluorite	0.51	Sulfides:	
		Chalcocite	18.78
		Chalcopyrite	4.83
		Greenockite	0.60
Metallic Copper	6.96	Galena	0.24
		Sphalerite	–1.45
		Pyrite	–7.87

Table A-11.
1:4 Mix of Terry and American Tunnels Water
Water mix with and without precipitation in flooded mine
(This table gives the results of MINTEQA2 modeling.)

	Mixed Waters no precipitation mg/L	*Mixed Waters precipitated mg/L*	*Relative Amount precipitated %*
$SO_4{-}{-}$	850	841	1.1
HCO_3-	123	106	13.4
Cl−	0.10	0.10	0.0
F−	3.49	1.00	71.4
Ca++	364	361	0.7
Mg++	7.0	7.0	0.0
Al+++	1.12	ND	100.0
Na+	2.74	2.74	0.0
K+	0.28	0.28	0.0
H_4SiO	5.81	0.06	99.0
Mn	22.0	7.07	67.8
Zn++	13.5	3.63	73.1
Fe	4.58	ND	99.9
Cu	1.02	ND	100.0
Sr++	3.22	3.22	0.0
Pb++	0.23	0.01	96.3
Cd++	0.07	ND	99.8
pH	7.06	7.32	
pE	−2.2	−2.2	

Minerals Precipitated:	*moles precipitated per liter of solution*	*mg precipitated per liter of solution*
Rhodochrosite	2.72E−04	31.3
Sphalerite	9.15E−05	8.9
$ZnSiO_3$	5.99E−05	8.5
Hematite	3.64E−05	5.9
Fluorite	6.60E−05	5.2
Diaspore	4.16E−05	2.5
Cuprous ferrite	9.15E−06	1.5
Chalcocite	3.47E−06	0.6
Galena	1.07E−06	0.3
Greenockite	6.22E−07	0.1

sunny\wp\traci\2251\A−11F.WK3

SIMON HYDRO-SEARCH

Table A–12.
1:1 Mix of Terry and American Tunnels Water
Water mix with and without precipitation in flooded mine
(This table gives the result of MINTEQA2 modeling.)

	Mixed Waters no precipitation mg/L	*Mixed Waters precipitated mg/L*	*Relative Amount precipitated %*
SO_4^{--}	735	723	1.6
HCO_3^-	79.5	61.2	23.0
Cl^-	0.18	0.18	0.0
F^-	4.27	1.09	74.5
Ca^{++}	287	284	1.2
Mg^{++}	11.5	11.5	0.0
Al^{+++}	1.90	ND	100.0
Na^+	2.35	2.35	0.0
K^+	0.63	0.63	0.0
H_4SiO	5.62	0.05	99.0
Mn	43.0	26.5	38.4
Zn^{++}	26.3	14.9	43.3
Fe	7.83	0.01	99.9
Cu	2.55	ND	100.0
Sr^{++}	2.38	2.38	0.0
Pb^{++}	0.54	0.02	97.1
Cd^{++}	0.12	ND	99.5
pH	6.98	7.00	
pE	−1.8	−1.8	

Minerals Precipitated:	*moles precipitated per liter of solution*	*mg precipitated per liter of solution*
Rhodochrosite	3.00E−04	34.4
Sphalerite	1.17E−04	11.3
$ZnSiO_3$	5.79E−05	8.2
Hematite	5.00E−05	8.0
Fluorite	8.39E−05	6.6
Cuprous ferrite	4.02E−05	6.1
Diaspore	7.05E−05	4.2
Galena	2.52E−06	0.6
Greenockite	1.02E−06	0.1

sunny\wp\traci\2251\A−12F.WK3

SIMON HYDRO-SEARCH

Table A–13.
Terry Tunnel reference water after equilibration to atmosphere and precipitation
(THESE VALUES GENERATED BY THE MODEL)

MINTEQA2 Component	Concentration mol/L	mg/L	Dominant Species
SO_4^{--}	5.668E−03	544	SO_4^{--}
CO_3^{--}	1.288E−05	0.77	H_2CO_3 aq
Cl−	8.469E−06	0.30	Cl−
F−	2.929E−04	5.56	AlF_3 aq
Ca++	3.993E−03	160	Ca++
Mg++	7.821E−04	19.0	Mg++
Na+	7.401E−05	1.70	Na+
Al+++	1.142E−04	3.08	AlF_3 aq
K+	3.072E−05	1.20	K+
H_4SiO_4	6.028E−06	ND	H_4SiO_4
Fe+++	5.626E−08	ND	FeF++
Mn++	4.448E−06	ND	Mn++
Cu++	8.040E−05	5.11	Cu++
Zn++	7.288E−04	47.6	Zn++
Sr++	1.119E−05	0.98	Sr++
Cd++	1.692E−06	0.19	Cd++
Pb++	5.072E−06	1.05	Pb++
pH	2.60		
pE	19.68		

Precipitated Minerals:	moles precipitated per liter of solution	mg precipitated per liter of solution	Minerals near saturation:	S.I.
Pyrolusite	1.41E−03	122.93	Mg−Nontronite	−0.42
Hematite	1.05E−04	16.78	Gypsum	−0.48
Ca−Nontronite	1.34E−05	5.72	Anglesite	−0.50
			Anhydrite	−0.89
			Quartz	−0.90
			Fluorite	−1.11
			Celestite	−1.36

sunny\wp\traci\2251\A−13F.WK3

Table A-14.
4:1 Mix (American Tunnel to Terry Tunnel) of reference waters after equilibration to atmosphere and precipitation
(THESE ARE VALUES GENERATED BY THE MODEL)

MINTEQA2 Component	*Concentration mol/L*	*mg/L*	*Dominant Species*
SO_4^{--}	8.849E-03	850	SO_4^{--}
CO_3^{-}	5.566E-04	33.4	HCO_3^{-}
Cl^{-}	2.823E-06	0.10	Cl^{-}
F^{-}	5.238E-05	1.00	F^{-}
Ca^{++}	9.013E-03	361	Ca^{++}
Mg^{++}	2.892E-04	7.03	Mg^{++}
Na^{+}	1.190E-04	2.74	Na^{+}
Al^{+++}	8.842E-09	ND	$Al(OH)_3$ aq
K^{+}	7.169E-06	0.28	K^{+}
H_4SiO_4	2.387E-08	ND	H_4SiO_4
Fe^{+++}	3.561E-15	ND	$Fe(OH)_2^{+}$
Mn^{++}	2.464E-16	ND	Mn^{++}
Cu^{++}	4.063E-06	0.26	$Cu(OH)_2$ aq
Zn^{++}	1.373E-04	8.98	Zn^{++}
Sr^{++}	3.681E-05	3.23	Sr^{++}
Cd^{++}	6.526E-08	0.01	Cd^{++}
Pb^{++}	8.555E-07	0.18	$PbCO_3$ aq
pH	7.82		
pE	14.18		

Precipitated Minerals:	*moles precipitated per liter of solution*	*mg precipitated per liter of solution*	*Minerals near saturation:*	*S.I.*
Pyrolusite	4.01E-04	34.88	Gypsum	-0.04
$ZnSiO_3$	6.04E-05	8.55	Calcite	-0.07
Hematite	4.10E-05	6.55	Cerussite	-0.11
Fluorite	6.60E-05	5.15	Brochantite	-0.42
Tenorite	1.20E-05	5.10	Anhydrite	-0.42
ZnO (Active)	9.37E-06	4.24	Smithsonite	-0.55
Diaspore	4.16E-05	2.49	Malachite	-0.64
Otavite	5.58E-07	0.10	Celestite	-0.72
Plattnerite	2.55E-07	0.06		

Table A-15.
1:1 Mix of American Tunnel and Terry Tunnel reference waters after equilibration to atmosphere and precipitation
(THESE ARE VALUES GENERATED BY THE MODEL)

MINTEQA2 Component	*Concentration mol/L*	*mg/L*	*Dominant Species*
SO_4^{--}	7.647E-03	735	SO_4^{--}
CO_3^{--}	2.320E-04	13.9	HCO_3^-
Cl^-	4.941E-06	0.18	Cl^-
F^-	5.713E-05	1.09	F^-
Ca^{++}	7.089E-03	284	Ca^{++}
Mg^{++}	4.741E-04	11.5	Mg^{++}
Na^+	1.022E-04	2.35	Na^+
Al^{+++}	8.521E-09	ND	$Al(OH)_3$ aq
K^+	1.600E-05	0.63	K^+
H_4SiO_4	5.025E-08	ND	H_4SiO_4
Fe^{+++}	5.423E-15	ND	$Fe(OH)_2^+$
Mn^{++}	1.410E-15	ND	Mn^{++}
Cu^{++}	3.832E-06	0.24	$Cu(OH)_2$ aq
Zn^{++}	3.443E-04	22.5	Zn^{++}
Sr^{++}	2.720E-05	2.38	Sr^{++}
Cd^{++}	3.485E-07	0.04	Cd^{++}
Pb^{++}	2.147E-06	0.44	$PbCO_3$ aq
pH	7.43		
pE	14.57		

Precipitated Minerals:	*moles precipitated per liter of solution*	*mg precipitated per liter of solution*	*Minerals near saturation:*	*S.I.*
Pyrolusite	7.82E-04	68.00	Tenorite	-0.08
Hematite	7.01E-05	11.20	Gypsum	-0.16
$ZnSiO_3$	5.84E-05	8.27	Anhydrite	-0.54
Fluorite	8.40E-05	6.56	Malachite	-0.80
Diaspore	7.05E-05	4.23	Celestite	-0.87
Brochantite	9.09E-06	3.86	Smithsonite	-0.87
Otavite	6.76E-07	0.12	Calcite	-0.94
Cerussite	4.49E-07	0.12		

Table A-16. Comparison of modeled discharge water with chemistry of Cement Creek

Date	Source	Flow MGD	Field pH	Field Temp deg-C	Lab pH	Major Anions Sulfate	Bicarb	Fluoride	Chloride
05/31/89	Cement Creek	15.67	3.9	12.0	4.1	50		4.8	
07/02/87	Cement Creek	11.47	3.9	8.8	4.2	60	0.0	0.4	0.0
	4:1 Spring Wtr	0.11	7.8	9.0		850	33.4	1.0	0.1
	1:1 Spring Wtr	0.11	7.4	9.0		735	13.9	1.1	0.2
03/29/91	Cement Creek	0.32	4.2	5.0	4.5	462	0.0	2.2	3.1
02/11/91	Cement Creek	0.23	5.7	1.9	3.5	439	0.0	3.1	2.0

Date	Source	Major Cations Ca	Na	Mg	Al	K	Metals Iron (Diss)	Mn (Diss)	Zinc (Diss)	Copper (Diss)	Lead (Diss)	Cadmium (Diss)
05/31/89	Cement Creek	17	8.4	0.2	1.8	0.9	1.2	0.5	1.4	0.24	0.04	0.01
07/02/87	Cement Creek	16	1.0	4.0	0.8	0.0	0.7	1.0	3.8	0.13	ND	0.03
	4:1 Spring Wtr	361	2.7	7.0	0.0	0.3	0.0	0.0	9.0	0.26	0.18	0.01
	1:1 Spring Wtr	284	2.4	11.5	0.0	0.6	0.0	0.0	22.5	0.24	0.44	0.04
03/29/91	Cement Creek	147	2.3	14.1	5.2	0.6	0.3	6.8	6.0	0.26	0.25	0.02
02/11/91	Cement Creek	135	4.1	15.2	6.7	0.7	1.1	8.3	7.4	0.40	0.29	0.07

Cement Creek water quality after bulkhead installation:		Major Anions Sulfate	Bicarb	Fluoride	Chloride	Major Cations Ca	Na	Mg	Al	K
High flow and 4:1 mix	13.68	61	0.3	2.9	0.0	19	5.3	1.8	1.4	0.5
Low flow and 4:1 mix	0.385	566	9.5	2.1	1.9	205	3.0	12.4	4.2	0.5
High flow and 1:1 mix	13.68	60	0.1	2.9	0.0	19	5.2	1.9	1.4	0.5
Low flow and 1:1 mix	0.385	533	4.0	2.1	1.9	183	2.9	13.7	4.2	0.6

Cement Creek water quality after bulkhead installation:	Metals Iron (Diss)	Mn (Diss)	Zinc (Diss)	Copper (Diss)	Lead (Diss)	Cadmium (Diss)
High flow and 4:1 mix	1.0	0.7	2.4	0.19	0.02	0.02
Low flow and 4:1 mix	0.5	5.3	7.3	0.30	0.24	0.03
High flow and 1:1 mix	1.0	0.7	2.5	0.19	0.03	0.02
Low flow and 1:1 mix	0.5	5.3	11.1	0.30	0.32	0.04

SIMON HYDRO-SEARCH

APPENDIX D

Petrographic Data from Proposed Bulkhead Sites core. The fracture is old, but quite open with six obvious voids as much as 10mm long by 2 mm wide.

This core is <u>not</u> typical in that is also contains numerous open voids not associated with any fracture. These voids are as large as 2mm in diameter. The voids are generally within 15mm of the open fracture.

A tight, hard to distinguish fracture contains one void 2mm long and ½mm wide. No blast damage.

<u>F-Level Brennaman, South Rib</u>
This core is crossed diagonally by 4 old fractures. These fractures contain numerous open vugs up to 6mm long and 2mm wide. In addition, there are scattered open vugs up to 2mm in diameter which are not associated with fractures. There is not blast damage.

<u>Terry Tunnel (F-Level), Back</u>
Core is crossed diagonally by an open, fresh looking fracture which looks very much like recent (blast?) damage. Otherwise the rock appears very tight.

<u>Terry Tunnel (F-Level), North Rib</u>
Core shows no fractures whatsoever. Rock contains disseminated pyrite (less than 1mm across) and numerous phenocrysts up to 4mm.

<u>Terry Tunnel (F-Level), South Rib</u>
Top 15mm of core is a vein of white mineral with one open void 4mm across.

Core is crossed by 2 old looking fractures which contain white mineral. No blast damage is evident.

The core is about 11 inches long. The core has a large nick out of it 2½ inches from the bottom. A fresh looking fracture comes off of this nick and goes directly across the core following a veinlet of white mineral.

<u>American Tunnel, Back</u>
This core has parts of 2 fractures crossing it. Neither fracture is positioned so as to have a major effect on a permeability test. The fractures appear old, but contain only a minimal amount of white mineral. The rock appears quite tight otherwise.

<u>American Tunnel, North Rib</u>
The rock is essentially unfractured. A very thin, tight veinlet of white mineral crosses the core diagonally. A slightly more open looking fracture exists near the top of the core, but should not affect the permeability test.

The rock appears very tight. It contains disseminated pyrite and obvious light phenocrysts up to 3mm long.

<u>American Tunnel, South Rib</u>
The core is split in half (lengthwise) by an obvious, fresh-looking fracture. The fracture appears open along its entire length and it is surprising the core doesn't fall apart. This fracture could well be blast damage.

Tight mineralized veinlets cross the core at a shallow angle. These are old and appear sealed.

This core contains more sulfides than the other cores, with pyrite blebs as large as 3mm across.

TABLE 1
SUMMARY OF ROCK PROPERTIES RELATED TO DURABILITY IN ACID WATERS

Sample No.	Location	Rock Type	Alteration	% Altered (non-Q)	Veins or Fractures: %	V or F	Spac-ing/mm	Thick-ness	Soluble Minerals
10	T.T., T-13	Andes Por.	Prop	48	tr	F	0.04*	0.8 mm	0%
11	T.T., T-15 + 300' to portal.	Andes Por.	Prop	33	3	V	0.10	1.2 mm	90%

LEGEND
* = Veinlets/mm
A.T. = American Tunnel
Andes = Andesite
B.V. = Brennaman Vein
Bx = Breccia
Carb = Carbonate
F = Fractures
L = Left
Ph = Phyllic
Por. = Porphyry
Prop = Propylitic
R = Right
T.T. = Terry Tunnel
V = Veins

PETROGRAPHIC DESCRIPTIONS

SH-10; Moderate Propylitically Altered Andesite Porphyry.

Andesite (99+%):

Phenos (68%);

58% Plagioclase (Pl)	0.2-2.6mm	Subangular tabular crystals. Tr-55% replaced with patches of epidote (Ep) ± chlorite (Chl) ± carbonate (Car) ± magnetite (Mt). Cores of largest phenos totally replaced.
10% Ferromags	0.2-3.0mm	Sub-euhedral relict crystals. 100% replaced with Chl > Ep (on edges) > leucoxene or to Ep = Car > leucoxene > Chl > pyrite (Py).

Porphyroblasts (2%);

2% Pyrite (Py)	<0.02-0.3mm	Cubic euhedra scattered throughout groundmass and phenos. Predominately replaced by leucoxene >> hematite. Also leucoxene as very fine-grained particles in turbid, occasionally euhedral 1u to 0.25mm patches.

Groundmass (30%);

15% Feldspar	0.02-0.2mm	Subhedral tabular crystals tr-50% replaced by Ep in patches. Turbid due to incipient alteration to very fine-grained mineral inclusions and pores. Predominately plagioclase (Pl).
10% Chlorite (Chl)	1u-0.2mm	Green flakes to masses interstitial to Pl and replacing small relict ferromags in groundmass. Pennine.
5% Epidote (Ep)	1u-0.2mm	Subhedra scattered through Pl.

Veinlet (tr):

	0.04mm thick	The only veinlet seen in thin section is Q filled, annealed, indistinct and discontinuous.

Fractures (tr):

See below.

This rock is generally cloudy in thin section (t.s.) due to abundant secondary alteration pores. Magic marker was absorbed up to 0.4mm depth on epidote-lined fracture surfaces.

SH-11; Propylitic-Altered Andesite Porphyry.

Andesite (97%):

Phenos (12%);

10% Feldspar (F)	0.6-3mm	Subhedra. 10-100% replaced by Car >> sericite (Ser) + Ep + Py.
2% Ferromag	0.6-1.4mm	Indistinct relict anhedra. 100% replaced by Chl + Py + Ep.

Groundmass (82%);

77% Plagioclase	0.05-0.6mm	Un-oriented tabular subhedra contain abundant inclusions of alteration minerals listed below.
15% Chlorite	<0.1mm	In polycrystalline patches replacing ferromags and interstitial to Pl.
5% Epidote	1u-0.25mm	Predominately coarser tabular subhedra in clumps in small Pl and ferromags.
3% Muscovite	<20u	Flakes disseminated in Pl.
tr Apatite	0.04-0.2mm long	Scattered prisms.
tr Hematite (Ht)	<3u	As stain and clusters of flakes in rare patches.
tr Leucoxene	<10u	Grains in small clusters throughout groundmass.

Porphyroblasts (3%);

3% Pyrite	0.04-0.6mm	Cubes in phenos and groundmass. Concentrated in ferromag phenos.

Veins and Veinlets (3%):

	0.04-1.2mm	In many directions and commonly cross. Early, type A is Ep-filled. Later, type B are thin and contain Q > Ep. Type C is thick, linear, appears last, is offset and contains Car > Py + Q + Ep.

The total Car content of the rock excluding veins is estimated to be 5% and is in altered Pl phenos.

APPENDIX E

Acid-Generation Testing of Secondary Mineral Crusts

McCLELLAND LABORATORIES, INC.

1016 Greg Street, Sparks, Nevada 89431 702 / 356-1300
FAX 702 / 356-8917

Report
on
Acid Generation Potential - Brenneman Samples
MLI Job No. 1893
February 11, 1993

for

Mr. Mark Stock
Simon Hydro-Search
5250 S. Virginia Street, Suite 280
Reno, NV 89502

SUMMARY

A total of six samples were submitted for paste pH measurement and special short term acid generation potential evaluation.

Paste pH for samples 3, 4, and 5 were low at pH 2.49, 3.11, and 3.56, respectively. This data would indicate a potential for acid production. However, it is thought that low paste pH was a function of acid salts contained in the solution phase of the moist samples, and not a function of the solids producing acid. Paste pH for samples 1, 2, and 6 was 4.62, 6.10, and 6.50, respectively.

Special acid generation potential scoping tests were conducted on five of the six samples. An insufficient quantity of sample six was available for evaluation. The data correlated well with paste pH data and indicated that acid pH encountered early in the cycle was a result of acid salts in residual moisture when the samples were taken. Slurry pH remained fairly constant after two hours, and demonstrates that the solids did not produce acid during the term of the test.

SAMPLE PREPARATION AND PASTE pH MEASUREMENTS

Samples were dry upon receipt. Each sample was weighed, and was subsequently pulverized in a mortar and pestle to a nominal 10 mesh feed size. Samples were blended and split to obtain appropriate quantities of sample for paste pH measurement and acid generation tests. Samples for paste pH were submitted to Chemax

Laboratories.

A sample cross-reference is provided in Table 1. Paste pH results are shown in Table 2. The Chemax Laboratories paste pH report sheet is provided in the Appendix to this report.

Table 1. - Sample Cross-Reference, Brenneman Samples

Sample Number	Description
1	F-Level, 100' East of bulkhead site, local sulfates
2	Brown-black mud flowstone, localized, 100' Inby of bulkhead site
3	B-Level, proposed bulkhead site, localized shot flowstone, 2 x 6 foot zone
4	B-Level, proposed bulkhead, 1/4" thick local deposit, brown flowstone
5	B-Level, Washington Vein near Washington vertical shaft - wall scrapings 1/16" thick
6	D-Level, wall scrape, 2700 stope, localized flowstone

Table 2. - Paste pH Results, Brenneman Samples

Sample Number	Paste pH, sp
1	4.62
2	6.10
3	2.49
4	3.11
5	3.56
6	6.50

SCOPING ACID GENERATION TEST PROCEDURE AND RESULTS

Scoping bottle roll acid generation potential tests were conducted on samples 1 through 5 to empirically determine the potential of the solids to produce acid.

Tests were conducted by contacting 5 g of solids with 500 ml of stock solution for 24 hours. Each slurry was continuously agitated by rolling in a zero head space bottle. Slurry pH was measured at 2, 4, 6, 8, 12, and 24 hours.

The stock solution was prepared to simulate the buffering capacity of the mine site water by adding 0.0042 g $NaHCO_3$ per liter of deionized water. The pH of the deionized water before addition of $NaHCO_3$ was 5.4. The pH of the buffered stock solution 15 minutes after $NaHCO_3$ addition was 7.5.

The pH meter was standardized with pH 2, 4, and 7 buffer before each slurry pH measurement.

A control test was also performed to establish the pH drift of the stock solution. Procedures for the control test were exactly the same except that solids were not added to the stock solution.

Results from the scoping tests are shown in Table 3.

Table 3. - Scoping Acid Generation Potential Test Results
Brenneman Samples

Sample	Slurry pH					
	Sample Number					
Time, Hrs.	1	2	3	4	5	Control
2	6.65	6.00	3.00	3.65	5.60	7.30
4	6.50	5.90	2.90	3.55	5.70	7.40
6	6.50	5.95	2.80	3.50	5.75	7.30
8	6.65	5.90	2.80	3.50	5.70	7.30
12	6.65	6.05	2.80	3.50	5.80	7.30
24	6.60	6.05	2.75	3.45	5.70	7.10

Scoping test results show that initial decrease in slurry pH was likely caused by acid salts contained in the solution phase of the moist samples taken from the walls of the mine. Slurry pHs were fairly stable after two hours for all five samples, and indicates that the solids do not show a potential to produce acid. These data are consistent with paste pH data.

Gene E. McClelland

Gene E. McClelland
Metallurgist/President

McCLELLAND LABORATORIES, INC.

1016 Greg Street, Sparks, Nevada 89431 702 / 356-1300
FAX 702 / 356-8917

Addendum Report
on
Acid Generation Potential - Brenneman Samples
MLI Job No. 1893
March 11, 1993

for

Mr. Mark Stock
Simon Hydro-Search
5250 S. Virginia Street, Suite 280
Reno, NV 89502

SUMMARY

Initial results from the special acid generation potential tests conducted on five Brenneman samples indicated that samples 3 and 4 remained below pH 4.0 after 24 hours of contact with weakly buffered deionized water at a 100:1 solution to solids ratio. Additional tests were conducted on the original slurries of samples 3 and 4 using a 1,000:1 ratio to determine potential to produce acid.

Results show that at a 1,000:1 ratio sample 4 did not produce acid. Slurry pH increased 3.4 to 6.7 after 24 hours of contact with fresh buffered stock solution. The slurry pH for sample 3, at the 1,000:1 ratio, remained below pH 4.0. Slurry pH increased from 2.7 to 3.6 with 24 hours of contact with fresh buffered stock solution.

An additional test was conducted on the sample 3 slurry using a 10,000:1 solution to solids ratio. Slurry pH increased from 3.6 to 5.0 after 24 hours of contact with buffered stock solution at the 10,000:1 ratio.

SCOPING ACID GENERATION TEST PROCEDURES AND RESULTS

Slurries at the 100:1 ratio lay idle for 20 days after the initial 24 hour agitated acid generation tests were completed. After 20 days, slurries were agitated for 1 hour and slurry pHs were measured. Results comparing slurry pHs before and after 20 days without agitation are shown in Table 1.

Table 1. - Slurry pH Data, Brenneman Samples, 100:1 Ratio

Contact Time	Slurry pH Sample Number 1	2	3	4	5	Control
24 Hours	6.60	6.05	2.75	3.45	5.70	7.10
20 Days, idle	6.10	5.95	2.70	3.40	5.50	6.75

Slurry pHs remained stable even after 20 days of contact with solution at the 100:1 solution to solids ratio. These data indicate that none of the solids generate acid, even though slurry pHs for samples 3 and 4 remained below pH 4.

Samples 3 and 4 were selected for additional evaluation using a 1,000:1 solution to solids ratio. Initial slurries (100:1) were diluted with fresh buffered stock solution (0.0042 g/l $NaHNO_3$ in deionized water) to obtain a 1,000:1 solution to solids ratio. Test procedures were the same as described in MLI report data February 11, 1993, except that slurry pH was measured at 0, 12, and 24 hours. A total of 500 ml of initial slurry was mixed with 4.5 liters of fresh stock solution.

Results from the 1,000:1 ratio tests are provided in Table 2.

Table 2. - Scoping Acid Generation Potential Test Results
Brenneman Samples, 1,000:1 Ratio

Sample Time, hours	Slurry pH Sample Number 3	4
0	3.7	5.1
12	3.7	6.5
24	3.6	6.7

Results show that sample 4 did not generate acid. Slurry pH increased from 3.4 (100:1 ratio after 20 days) to 6.7 with 24 hours of contact with stock solution at the 1,000:1 ratio. Slurry pH for sample 3 increased from 2.70 (100:1, after 20 days) to 3.6. The one pH unit increase roughly corresponded to the additional 10 to 1 dilution ratio. The data does not, however, demonstrate that sample 3 solids produce acid while in contact with a weakly buffered deionized water solution.

An additional test was conducted on the sample 3 slurry using a 10,000:1 solution to solids ratio. The slurry from the 1,000:1 ratio was again diluted 10:1 with fresh stock solution by adding 500 ml of slurry to 4.5 liters of fresh stock solution. Results for the 10,000:1 ratio test are provided in Table 3.

Table 3. - Scoping Acid Generation Potential Test, Brenneman Sample 3, 10,000:1 Ratio

Sample Time, hours	Slurry pH
0	5.5
12	5.3
24	5.0

Results show that slurry pH decreased slightly with time, but at the 10,000:1 ratio, final pH was 5.0. Decrease in slurry pH can be attributed, in part, by the weak buffering capacity of the stock solution, and by contact with CO_2 in air. Stock solution pH decreased from 7.2 to 6.9 during the 24 hour period. That data does not demonstrate that decrease in pH was caused by acid produced by the solids.

Gene E McClelland

Gene E. McClelland
Metallurgist/President